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Norman G. Shidle
Editor

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EDITORIAL OFFICE
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ADVERTISING OFFICES
E. L. Carroll
Eastern Advertising Manager
29 West 39th St.
New York 18, N. Y.
Tel.: LOngacre 5-7170

A. J. Underwood
Western Advertising Manager
3-210 General Motors Bldg.
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SAE DETROIT OFFICE
808 New Center Bldg.
Tel.: TRinity 5-7495
R. C. Sackett, Staff Representative

SAE WEST COAST BRANCH
Petroleum Bldg.
714 W. Olympic Blvd.
Los Angeles 15, Calif.
Tel.: Prospect 6559
E. W. Rentz, Jr., West Coast Manager

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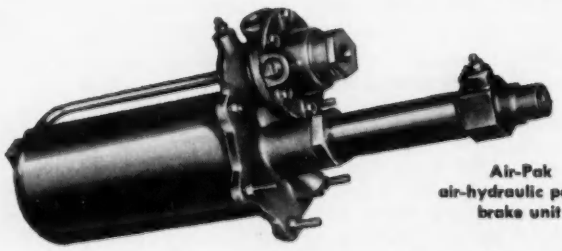
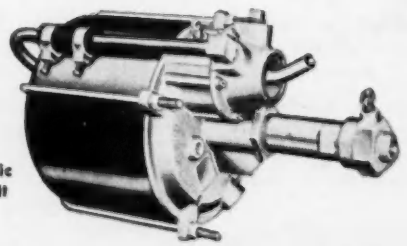


Air-Pak air-hydraulic power brake unit



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The Engineer Is Quite A Fellow!

EXCERPTS FROM PAPER BY

Harry J. Klingler, Vice-President, General Motors Corp.

• Paper, "Engineering and Management," was presented at SAE Passenger Car, Body, and Materials Meeting, Detroit, March 8, 1951.

In this article, management looks at the engineer through the eyes of a sales-trained executive who recently completed 17 years as general manager of Pontiac

COMMUNICATION between management and engineering should be a two-way circuit. They sometimes look upon each other with what appears to be a mild suspicion and intolerance. If this situation sometimes exists, then the result can only be a regrettable loss—to engineering, to management, and to the consumers.

Chief engineers should accompany management on many sales trips—however boring and tedious they may appear from a purely engineering viewpoint. There should be a reserved seat for engineers at each company's dealer meetings. They should be invited to sit in on some advertising conferences and learn the language that is spoken there. . . . . and it goes without saying that they should be present whenever important manufacturing decisions are made.

Sales trips, dealer meetings, advertising conferences . . . . . engineers should take part in these things occasionally. They represent an important operation in the automobile business—the distribution of the finished product. And that is the end product of our business. For no matter how well-engineered a product is—no matter how well it is manufactured—it is a dead loss until it is placed in the hands of the user.

Engineers have a tremendous professional advantage over sales managers or general managers. Engineers can go part way—or a long way—toward solving their problems by textbooks or the slide rule . . . . the guideposts along a well marked highway. But I've never yet found a common pool of knowledge on how to be a good sales manager or a good general manager. The guideposts, if any, are vague. Thus, managers must be opportunists, dealing with changing affairs of the moment plus all the intangible elements of human behavior.

I have seen all types of men succeed as managers. They have been far different in their thinking, in their appearance, in their manners, and in their backgrounds. But they have had one thing in common: they have been experts in human relationships. They have this ability to get along—to handle men—in their heads and in their hearts.

To accomplish his job, a good manager must have the cooperation and trust of the engineer—who brings to management the disciplined mind of a true professional man. A good engineer *wants to know* . . . and usually does. Before he releases something for production, he pretty well knows it is going to work. (If he doesn't, of course, it can always be that those factory fellows slipped up again!)

Yes, an engineer is a valuable man in any worthwhile management setup.

Securing this cooperation is the job of the general manager. He must invite his engineers to sit in with his overall operations. For engineers are human. They rarely go where they are not invited. But they might make themselves available for invitations. Why shouldn't an engineer suggest in a high-grade way that he would like to sit in on meetings concerned with aspects of the business other than engineering. He may be surprised how pleased the boss will be at his request.

A great responsibility of management is mer-

chandising—and it is a tricky subject. In so-called normal times, merchandising is concerned with profitably distributing a surplus of product. During the last decade—for the more fortunate automobile manufacturer—the merchandising problem has been how to distribute a shortage equitably.

Merchandising and good engineering must go hand in hand if any product is to be successful. And this is particularly true in the automobile industry where fierce competition exists even in times of shortage. What engineers dream and create—no matter how valuable and needed—must be sold to the public—which usually is not too eager to be convinced of the value and need of anything new.

The automatic transmission was an example. Some forms of automatic transmission have been in existence for years. But in the past few years, acceptance by the public has come with a rush. This sudden acceptance didn't just happen. It was the result of constant merchandising and constant engineering refinement. Both these activities were carried on until the public was in the proper frame of mind to accept the automatic transmission and the product itself was worthy of widespread public acceptance.

If merchandising and engineering are properly timed, then success for the product is assured. If one lags behind the other, the result is often disastrous.

What's Ahead in Design?

It is fascinating to speculate on what the engineers will bring into being in the next quarter century. By the very nature of his profession, he must project himself into the future. The past is history. It has been done. Spending too much time and thought on the past is like driving a car by looking in the rear-view mirror.

In dealing with the future, though, we must keep our imaginations in leash. Because the customer's desires are deeply rooted in the past, he is a creature of habit. Back in his mind, he still thinks that maybe the running board was a good thing. He doesn't want to swoop down to the grocery in a jet plane or even a flying saucer. His basic desire still is a four-door sedan which starts well on cold mornings, that he can see out of, and which is easy on the gasoline and repair bills. He is a pretty cagey character, this customer of ours.

If we can judge by his answers to questionnaires sent by the GM Customers Research Department, here are a few things he wants engineers to do for him:

- Better windshield wipers;
- More comfortable heating systems in which he is neither frozen nor fried;
- An easier way to change tires;
- More positive control of rear door locks;
- Better braking in wet weather;
- Better protection from headlight glare;
- Better keys and locks;
- Better seat adjustment;
- Better ventilation.

Perhaps in the next 10 years management and engineering—working together—can remove some of these annoyances.

Engineer is Quite a Fellow

Engineers are perhaps the least well known of professional men. But when you examine the qualifications of a good engineer, he is quite a fellow. Let's look at some of these qualifications:

A good engineer is intellectually and morally honest.

He has a deep interest in the product result—what is going to happen to it in the hands of the dealer and the public.

He is able to assemble facts, to investigate thoroughly, to discriminate clearly between assumption and proven knowledge.

He is a man of faith. He perceives difficulties and ways to surmount them. He is patient enough to explain the overall result he hopes to achieve.

He knows mathematics and mechanics and is trained to methods of thought based on these fundamental branches of learning.

He is a student throughout his career.

He does not occupy an ivory tower, but can explain his purposes to laymen in their language.

His work is never finished—because the world is never finished.

The engineer is quite a fellow!

See Page 58 . . . .

for complete editorial coverage of the SAE National Aeronautic Meeting and Aircraft Engineering Display.

A WARNING

Against making Germany's mistakes of wartime production of aircraft

EXCERPTS FROM PAPER BY

Woldemar Voigt, USAF Air Materiel Command

• Paper, "Working for Air Defense," was presented at SAE Annual Meeting, Detroit, Jan. 9, 1951.

MY experience as a responsible engineer in a German armament factory during World War II convinces me that military aircraft programs should keep planning flexible and give high priority to development. Germany's failure to do this led to collapse of its air defense and hastened defeat.

The story of the German failure begins with German planning and procurement in the years 1934–1937.

From the outset, German air force development was the result of one single defined planning operation. The government laid out requirements for all airplane types, then issued to industry. About three firms got development and prototype orders for each type.

When development orders for the single seat fighter were placed, the German government followed a policy which proved to be very successful: prototype orders were given, not only to two well established and "reliable" firms, but also to an outsider who had the reputation of following very progressive ideas, but of following them with such extremes that his airplanes would hardly be practical "work horses." It was expected that Messerschmitt would lose in the competition, but that he would be an excellent stimulant for the efforts and ingenuity of the other firms.

This development order to an extremist outsider certainly made the competition keen. Besides, Messerschmitt quite unexpectedly won the competition with the Me 109. Thus, the policy was a clear success.

Procurement of the airplanes of this phase followed the normal scheme: five prototypes were ordered after the firms' proposals had been received, followed by the order on 15 preproduction airplanes after the first phase of the flight testing, and increasing batches of production airplanes ordered at and after the last stages of the flight testing.

This concerted and well-planned development effort yielded the technical means to establish a modern and complete air force.

Then the policy of the government changed completely. High government planning and military planning concentrated exclusively on building up a strong well-trained air force at the earliest possible date, using the airplanes which had now been made available. *Technical development was no longer a part of the overall planning.*

Development beyond the "first generation" of airplanes was left to private initiative, fostered and paid for by the technical agencies of the Air Ministry, but not coordinated in any long-term planning.

The consequences of this lack of technical foresight were catastrophic.

Two important orders were placed in 1938. Both were initiated by studies and proposals made by private firms.

Heinkel submitted a study of development of a jet engine. The engineering division of the Air Ministry gave Heinkel development orders for it. At the same time, true to its basic policy, it placed orders with BMW and Junkers. Airplanes to be powered by these jet engines were ordered from Heinkel and Messerschmitt.

The jet development, however, did not find any interest and room in the German overall and military planning.

At the same time, Messerschmitt proposed the development of a fast twin-engined bomber which should have the speed, maneuverability and armament of a fighter and should therefore be an even match to attacking enemy fighters.

Contrary to the jet engine, the fighter-bomber was accepted at once by the overall planning. The

WOLDEMAR VOIGT was chief of preliminary design and aerodynamics for Messerschmitt during World War II. He saw German military aircraft planning develop, go into war . . . and fail.

In this dramatic story of why the Germans failed, he warns others against making Germany's fatal mistakes.

You don't have to be an aeronautic engineer to become engrossed as Voigt's eye-witness account unfolds.

requirements proposed by the firm were re-formulated and adapted to the actual military necessities by the general staff of the air force, and the development order for this airplane, the Me 210, was given.

In this order, the German government tried a new way to get more airplanes faster. It ordered a first production batch of 1000 airplanes right from the proposal drawing; it specified design changes according to the revised requirements and delivery of the 1000th airplane in 2½ years; and a limit of 10,000 man-hours for the 1000th airplane. Continued production at a rate of several hundred a month after this first batch had to be provided for.

The time schedule as ordered could not quite be met, for reasons of technical difficulties and a shortage of toolmakers; however, the plan proved sufficiently successful to be adopted for other important airplane developments.

September 1, 1939, World War II broke out.

The first measures taken by the government showed clearly that ceasing of development initiative after that "first generation" of airplanes was not an insignificant incident, but the expression of its ignorance of the necessities implied in the continuous progress of military engineering.

All long-term development projects were forbidden; stop-orders were issued for the development of the jet engines, the jet airplanes, and somewhat later also for radar and VHF developments.

The industrial planning of the German government concentrated completely on the strategic bomber; fighter production was continued at the low prewar rate. Development planning provided only the elimination of technical troubles becoming visible in combat service.

The policy to concentrate on being prepared at the one moment when war breaks out, without providing any development for keeping abreast with the events of the war itself, was a mistake of catastrophical consequences.

Two events between 1939 and 1941 were the first indications of two problems which were to play decisive roles in German industry in the next-following years.

(1) The procurement schedule of the Me 210 fighter-bomber was delayed by a shortage of toolmakers and machine tools. (2) War experience showed that even well-established airplane model require a tremendous effort for continuous technica adaptation to varying events and enemy moves, fa beyond the "elimination of technical troubles."

From 1942 to the end of the war, the toolmakin bottleneck and the modifications became dominat ing and controlling factors in German airplane de velopment and procuremnt.

The year 1941 marks the beginning of the decline of German power. It marks also the beginning of a new chapter in Germany's working for air defense, comprising the years 1941 to 1943.

German planning had to shift efforts more and more from air offensive to air defense. But still, the main weight of these efforts was put on production, no initiative and little interest being taken in development for air defense.

Production and stop-gap modifications dictated by momentary military necessities were the only fields in which the government concentrated efforts. Germany contented herself to be led by enemy initiative without trying to ultimately regain that initiative.

This policy of following the enemy's initiative automatically set off a chain reaction, steadily increasing the lead of the Allies and leading to disaster for the Germans.

The policy itself—and its consequences—were logical outflows of the basic weakness of German planning . . . . which had planned for a strong air force at a single particular moment—and had not provided at the outset for a healthy development thereafter.

Under the pressure of Allied superiority, the German government ordered a vast expansion of fighter production. It was the first great decision of German planning after a long period of improvisations and stop-gap measures. But its high initial impetus was immediately ground to a slow and very, very tough struggle—there were not enough toolmakers available.

German planning had not foreseen this bottleneck, had not provided for it. No recourse was possible to the toolmaking manpower of new developments. No such developments and no manpower for them had been provided.

This apparently insurmountable handicap was overcome, not by government planning and control, but by tremendous effort of human work. Designers and toolmakers worked like madmen to get tools into the shops. Production managers, engineers, and workmen performed superhuman work to achieve the apparently impossible.

The tremendous effort of the fighter-producing firms and men brought some success. Fighter production climbed higher and higher in spite of all obstacles. For a while, the success of German air defense was good. But again, the weakness of the German planning lost that chance. Development of radar and VHF communications had been forbidden, and now the ground control was unable to make efficient use of the many fighters available. The jet fighter development had also been neglected and forbidden, and now the German fighters suffered heavy losses from the Allied escort fighters.

The increased output was not sufficient to balance these technical handicaps.

On the engineering side, remarkable progress was made in rationalizing production. That was achieved not only by developing new and improved production methods but also by designing and redesigning airplanes, and modification especially for the toolmaker and the production planner.

The concentrated effort in fighter production strengthened for a while the German air defense to such an extent that the situation even looked rather hopeful.

In the development field, work dragged along as "private venture" of firms and government engineers only within the limits of raw material and manpower not used in the production.

The designers constituted a bottleneck in development just as the toolmakers in production, and for similar reasons. The overall plan had not considered any new development.

Era of Omnipotent Administrators

At the end of 1943, the insufficiency of the German air defense and of the industrial output became so obvious that something had to be done about it.

Thus, and only at that late stage of the war, the era of the industrial dictators, of the omnipotent administrators of certain programs, broke out. As the first step the "Fighter Authority" ("Jaegerstab") was founded with the purpose of accelerating the fighter production to the utmost.

Till that time, the German aircraft industry operated practically as private enterprise. The totalitarian power of the government existed virtually on paper only, since no person holding a higher position was prepared to actually give strong orders to industry and to enforce them. More than that nobody even dared giving orders and decision for which industry actually asked.

The newly installed Fighter Authority was organized differently:

1. Its decisive men and their staff were engineers and production managers of highest qualifications.
2. Its chain of command was cut very short; it reported immediately to the minister of Industrial War Production and to Hitler.
3. The military influence on production was organized the same way: a "General of the Fighters" was installed as the central authority presenting the demands and problems of the air force to the "Fighter Authority."

The General of the Fighters reported to the Minister of the Air.

Differences between these technical and military authorities were decided by Hitler himself.

Because of the paramount importance of the air defense in that stage of the war, this Fighter Authority and its successors were given the power to break into other fields of production and to requisition raw materials and man-power without much regard to the consequences in those other fields.

Again, just as in all the preceding years, the concerted effort was concentrated on production, and development was again left aside.

However, the jet fighter ME 262, which had just been completed in its unplanned development, was now included in the production program.

The fighter output was pushed up to more than 3000 a month, more than American and British production combined; the output of the repair works brought the total up to 4500. Also the jet fighters started to come in appreciable numbers.

Then came one of those ununderstandable moves which had already happened so often in Germany.

Hitler decreed that the first jet fighter was not a fighter but a bomber. All jet fighters were converted to bombers, crews were trained, and then they were used to drop 1000 lb bombs somewhere in Beligum. Meanwhile, 1000 to 2000 bombers flew every day over Germany, destroyed the towns and the factories working for the air defense. German fighters were practically unable to penetrate through the fighter escort and to get at the bombers at all. The average life of a fighter airplane dropped to four hours in the air, so high did the fighter losses go up.

For us engineers, this decision of Hitler's opened up a new phase in our work. Our technical work had become largely meaningless, and we decided in long discussions that we had now to do more than that. Officers of the Luftwaffe came obviously to similar conclusions.

The officer commanding the Me 262 "bombers" penetrated to Hitler and tried to talk him out of that bomber use of valuable jet fighters. Other people tried similar ways.

As a result, bomber use of jet fighters was finally cancelled. . . . But too late. The onslaught of the Allies had become crushing. Any work for defense had become useless.

Planning and organization of German air defense was a madhouse during the last six months of the war.

My conclusions, resulting from these experiences, are:

1. It was a basic mistake to plan for one certain stage of the technical art only and not to plan and provide for technical development. An advanced stage of development should have been initiated as soon as one stage had become technically clear.
2. It was a basic mistake to plan rigidly for one anticipated course of events. It would have been necessary to provide for revisions of the plan itself and to keep sufficient reserves available, especially designers and toolmakers, to make such program revisions effective.
3. It was a mistake to believe in technical planning and control by an impersonal "Administration," consisting of "officers" instead of prominent and technically competent personalities.
4. It was a successful move, made repeatedly, to invite competition of an imaginative, although apparently hopeless, outsider to keep well established contractors keen and to widen the scope of investigation and development.
5. Throughout the period, private initiative has always been stronger and better than the government initiative in a so-called "planned economy." The Government's initiative became effective and dominated only when it was delegated to competent men out of private economy and was used in normal industrial and business-like organization.

(Paper on which this abridgment was based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

How Rubber Is Matched

BASED ON PAPER BY

J. W. Liska, Assistant Director, Chemical and Physical Research Laboratories, Firestone Tire and Rubber Co., Akron, Ohio.

• Paper, "Automotive Applications and Special Features of Synthetic and Natural Rubbers," was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

Table 1—Some Basic Qualities of Natural and Certain Synthetic Rubbers

	Natural Rubber	GR-S	Neoprene GN	Nitrile Rubber	Butyl Rubber
Tensile strength ("gum" formulation)	High	Low	High	Low	Med. to High
Tensile strength (reinforced)	High	Med. to High	High	High	Med.
Ultimate elongation (reinforced)	High	Med. to High	High	Med. to High	High
Stiffness (reinforced)	High	High	High	High	Med. to High
Resilience (reinforced)	High	Med. to High	Med. to High	Med.	Low
Resistance to swelling by mineral oils and fuels	Low	Low	Good (except aromatics)	Excellent (except ketones)	Low
Resistance to ozone attack	Med.	Med.	Good	Med.	Excellent
Resistance to oxidative aging	Good	Good	Good	Good	Good
Resistance to heat aging	Med. to Good	Good	Very Good	Good	Med.
Flexing resistance	Good	Med. to Good	Good	Med. to Good	Good
Low-temperature properties	Good	Med.	Poor	Poor	Med. to Good
Permeability to gases	Med.	Med.	Med.	Med.	Low
Permanent set	Low	Low to Med.	Low to Med.	Med.	High
Creep under load	Low to Med.	Low to Med.	Low to Med.	Med.	High
Compatibility with other rubbers	Good	Good	Good	Fair	Poor
Resistance to tear	High	Low to Med.	Med. to High	Low to Med.	Med. to High

to Product Requirement

SKILLED rubber technologists are in an excellent position today to propose rubber materials and compounds for evaluation in specific applications.

In proposing the "best" rubbers for a given product, rubber experts must consider the range of characteristics which can be produced through compound variations. In many instances, a compounding variation which improves a stock with respect to one physical characteristic simultaneously diminishes its quality with respect to one or more other characteristics. Because of this fact, compounders must almost always stop short of the ultimate in one property to avoid serious deterioration of some other property. Table 1 compares characteristics of natural rubber and some synthetic rubbers.

Besides physical characteristics of compounds, rubber technologists must also consider their availability, processability, usage restrictions imposed by the government for strategic reasons, and cost.

Material choice is determined first of all by anticipated service requirements. The compound containing the chosen basic material is then subjected to laboratory tests which are designed to simulate service conditions as closely as possible.

Since final acceptance of a product is, in most instances, based on an actual service test, the formulation employed or even the basic rubber used, is relatively unimportant. The rubber technologist should be given the greatest possible latitude in developing the compound. In the best interests of all, he should not be restricted by formulation or choice of rubber, so long as he is able to qualify the product under the conditions imposed by the service test.

Following are six examples of the general approach rubber technologists apply to the problem of selecting rubber compounds for the close-to-400 rubber parts used in modern passenger cars.

Product: Radiator Hose

REQUIREMENTS: Radiator hose must have a good flex life, now that development of improved engine mounts allows greater movement of the engine with respect to the radiator. Besides, there is a demand for resistance to ozone cracking.

The introduction of water-soluble oils to reduce evaporation of antifreeze and to inhibit corrosion places still further service demands on this product.

COMPOUNDS PROPOSED: Reference to Table 1 indicates that butyl and Neoprene GN compounds are superior to those made of natural rubber in the requirements enumerated.

From the standpoint of ozone resistance, butyl is outstanding, but because no satisfactory commercial methods for bonding it to other rubbers are known as yet, both (outer) cover and (inner) tube would have to be made of butyl if one of them is. Since the water swelling and oil resistance of butyl rubbers are not significantly better than those of natural rubber, such a product would be superior to a natural rubber hose only with respect to the service performance of the cover. Neoprene, while not as good as butyl from an ozone-resistance viewpoint, is considerably better than natural rubber from the standpoint of the tube requirements.

It would appear, therefore, that the best choice of rubbers in this case would be a neoprene tube and a neoprene cover, if cost considerations were completely neglected. Since the latter point cannot be overlooked, and since Neoprene GN is reasonably compatible with other rubbers, a neoprene tube and GR-S cover combination has been developed which is giving a good account of itself.

[No mention whatsoever has been made of the tensile strength or ultimate elongation of any of the compounds used in radiator hose. Though these have been used extensively in the past as "quality" indexes, the more realistic attitude adopted in recent years recognizes their unimportance in certain product applications.

More important are service tests. One service test for radiator hose consists of flexing the finished product through an amplitude of 3/8 in., while it is filled with a mixture of 3 parts water, 33 parts ethylene glycol, 33 parts ethyl alcohol and 1 part Ceco oil, at a temperature of 220 F and an internal pressure of 20 psi. To be acceptable, a hose must withstand these test conditions for a period of 80 hr without failure of any kind. The usual types of failure are

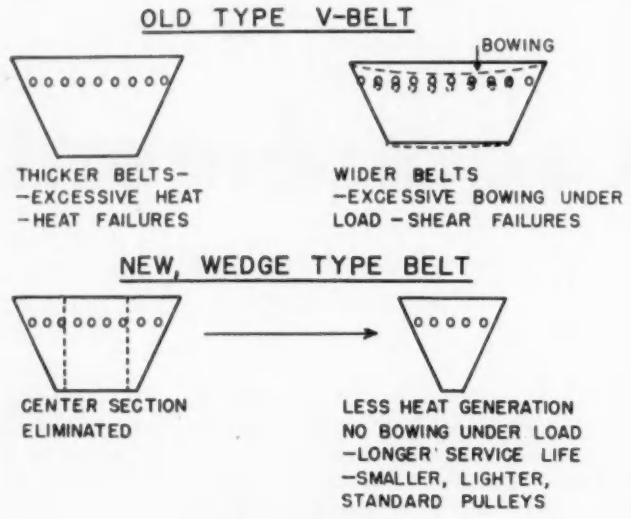

Fig. 1—Fan belt designs

bursting of the hose, blowing off of clamps, leaking clamps, or indications of the presence of sticky or otherwise soft material which might conceivably slough off and ultimately clog the cooling system.

Other service tests are similar and in some cases even include exposure to ozone as a further condition.]

Product: Brake Hose

REQUIREMENTS: Automotive brake hydraulic hose must withstand exposure internally to commercial brake fluids and externally to salt spray. In addi- it must possess good flexing properties at temperatures extending down to -40 F.

COMPOUNDS PROPOSED: Since brake fluids contain no petroleum products, either natural rubber or GR-S is a satisfactory material for this application, with preference usually going to the former because of its superior flexibility at low temperatures.

Product: Fan Belts

REQUIREMENTS: Fan belts must have long flexing life and resistance to heat aging. Since friction, both internal and external, contributes a considerable fraction of the heat which the belt must withstand, the mechanical efficiency of the compound indirectly affects the choice of materials through its effect on heat aging.

COMPOUNDS PROPOSED: These requirements limit the choice of materials to natural rubber and Neoprene GN. Although GR-S has the necessary heat-aging qualities, its efficiency and rather poor tensile strength at high temperatures have precluded its successful use in fan belts to date.

[The most recent improvement in V-belts is in design of the part instead of the compound. Latest designs are for wedge-type belts.

For some time prior to this innovation, V-belt development had followed a rather erratic cycle. In order to reduce pressures and hence reduce heat failures, the widths of the belts were increased. This change, however, resulted in increased shear failures due to excessive "bowing," shown in Fig. 1. In order to reduce this bowing, the belt thickness was then increased. This in turn led to increased heat failures.

This cycle was finally broken by a reversal in development reasoning. Instead of adding to either thickness or width, material was removed from the center section of the belt. The new belt is much more nearly a "V" belt than the older trapezoidal type, which had a fairly wide base. It is smaller, lighter, longer lived, consumes considerably less power, will probably be less expensive, and has quite completely eliminated running noise and the idle-speed squeaks which were common complaints with the older type V-belt. To date, this type of belt is most successfully made with neoprene, but future developments will probably show that other materials (most likely natural rubber) can also be used.

The development of the new belt necessitated a great deal of experimental work. In agreement with earlier data on flat transmission belts, it was found, for example, that the life of a V-belt varies (1) inversely as the fourth power of the tension, (2) directly as the fifth power of the diameter of the pulley, and (3) inversely as the 0.5 power of the speed. Design engineers should hence provide the largest practicable diameter pulleys to ensure long belt life. Belts should also be properly tensioned and means provided for keeping the tension under control at all times.]

Product: Tires

REQUIREMENTS: Rubber compounds for tires must have durability, resistance to flexing, heat, humidity, and ozone.

COMPOUNDS PROPOSED: Recently, a new polymer and a new carbon black have greatly improved tire durability. The new polymer is GR-S manufactured at low temperatures. This low-temperature polymer (LTP) is the popularly known "cold rubber." The new fine-particle-size blacks are high-abrasion furnace or HAF blacks. LTP-HAF combinations yield treads giving up to 25 or 30% greater wear than is obtained with the best natural rubber or regular GR-S formulations containing standard (EPC) channel blacks. This has been achieved in passenger-car tires without sacrifice in tread cracking, heat generation, or other service characteristics. In fact, heat generation of the LTP-HAF tread is somewhat lower than that of a typical GR-S tread although not so low as that of a natural rubber tread. Conse-

quently, successful application of the new treads to heavy-duty, high-speed truck and bus tires has not yet been achieved.

[Equally important are improvements in the overall quality of body, sidewall, and tread compounds due to new antioxidants and vulcanization accelerators. The antioxidants minimize heat aging, flex cracking, and, in white sidewalls, discoloration. Accelerators permit more uniform vulcanization and new types of vulcanization. Both are steps toward lower net cost of product service.

Since ozone attack has been shown to be one of the major causes of sidewall cracking, extensive evaluations of materials designed to reduce ozone degradation have been carried out. Simultaneous studies have also been made on the effects of the factors causing weathering: heat, light, flexing, and humidity. Light, in the absence of ozone, has been found not to be a major cause of product failure. In fact, it has been shown to afford some degree of protection against subsequent ozone attack through the formation of a very thin film of minutely crazed rubber. Ozone attack appears to be more serious at low than at elevated temperatures, a finding of a especial importance in the development of automotive rubber products destined for service at Arctic temperatures. A number of methods and materials have been developed for reducing ozone attack under static conditions and a few are now available for protection even under dynamic service conditions.]

Product: Windshield Wiper Hose

REQUIREMENTS: Windshield wiper hose is not normally exposed to either water or oil. Virtually the only difference between windshield wiper hose specifications written by different customers is the modulus or stiffness.

COMPOUNDS PROPOSED: Stiffness specifications can be met easily by use of either natural rubber or GR-S. Selection is dictated almost solely by economic considerations. Either price or government restrictions on the use of natural rubber could cause almost all such hose to be made of GR-S.

Product: Tire Tubes

REQUIREMENTS: Prime requisite is ability to hold air.

COMPOUNDS PROPOSED: No commercial polymer has been found yet which even approaches butyl rubber in air-containing properties. Hence the application and continued use of this material for inner tubes appears quite secure, despite some rather serious defects, such as excessive "growth" and low-temperature buckling, which at one time threatened its position in this field. Both of these have been greatly lessened as a result of rather recent researches.

The present-day butyl tube with its excellent service characteristics, including good tear resistance, is a considerable improvement over the product of even a year ago.

Product: Fuel and Oil Hose

REQUIREMENTS: These hoses must withstand swelling and resultant deterioration by the liquid in contact.

COMPOUNDS PROPOSED: Examination of Table 1 shows clearly that only two materials, nitrile rubber and Neoprene GN, can even begin to qualify. Despite its higher cost, nitrile rubber is used almost exclusively in fuel hose, in preference to Neoprene, GN, because of its greater resistance to swelling. On the other hand, Neoprene GN is successfully employed in oil hose, since it has adequate resistance to swelling in this application and is less expensive than the nitrile rubbers.

It should be mentioned that a third oil-resistant synthetic rubber, Thiokol, is commercially available and is being used in limited quantities for rather special applications, such as gasket and tube coatings. Here advantage can be taken of its exceptionally high resistance to certain oils and solvents.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

D. P. BARNARD'S HORNING MEMORIAL LECTURE

is published in full in the April, 1951, issue of SAE *Quarterly* Transactions, which recently came off the press.

Titled, "The Role of Fuel in Engine Development," this lecture shows how the development of gasoline—by means of cracking processes, improvements in octane number, and the like—contributed to the overall success of the gasoline automobile.

Dr. Barnard is research coordinator for Standard Oil Co. (Ind.)

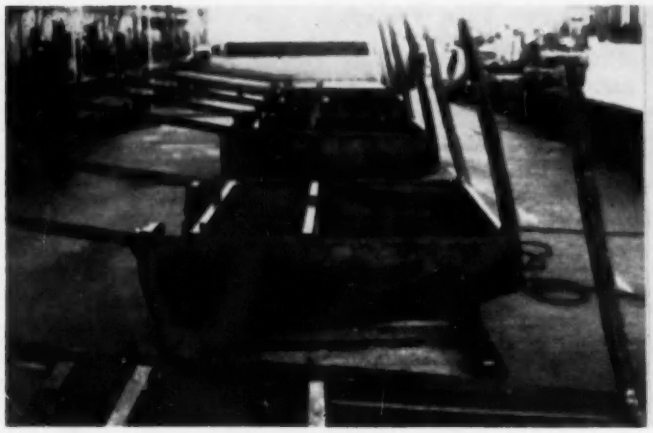

Fig. 1—Fuselage subassembly about which further assembly is made

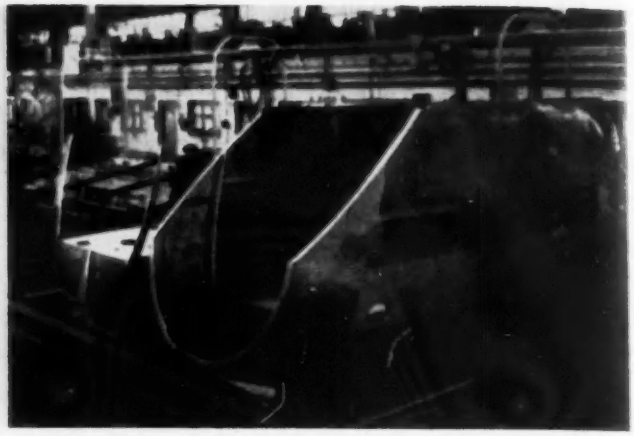

Fig. 2—Fuselage assembled without using large jigs and fixtures

Hole Production Method for Airframe Parts

BASED ON PAPER BY

August Bringewald, Chief Tool Engineer, Republic Aviation Corp.

• Paper, "German Aircraft Manufacturing Methods," was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

A NEW airframe mass production system eliminates the use of large jigs and fixtures on the assembly line. German engineers developed this "Hole Production Method" during World War II to save material and to reduce operation time and production space. The idea was to complete all the detail airframe parts, including rivet holes, before assembly so that no large jigs and fixtures would be necessary for assembly. Fabrication of minor and major assemblies was to be accomplished on racks moved on conveyor lines.

The proposed system presented many problems. Perhaps the most important was finding a way to produce accurate, finished parts before assembly for sensitive, three-dimensional airframe structures. Efforts to produce exactly matching tools and—as a sequence—accurate detail parts, led to the development of a so-called "Master Body."

The "Master Body" was the first example of an airframe component built to incorporate all details, such as bulkheads, stringers, stiffeners, ribs, spars, and the entire rivet hole pattern, including drill bushings. It was made with steel, electrically welded to prevent warpage.

Groups of tools developed from the "Master Body" were:

1. Templets for bulkhead and rib flanges
2. Cutting fixtures for bulkhead and rib flanges
3. Assembly and drill jigs for bulkheads and ribs
4. Cutting and drill jigs for stringers
5. Cutting and drill jigs for skins

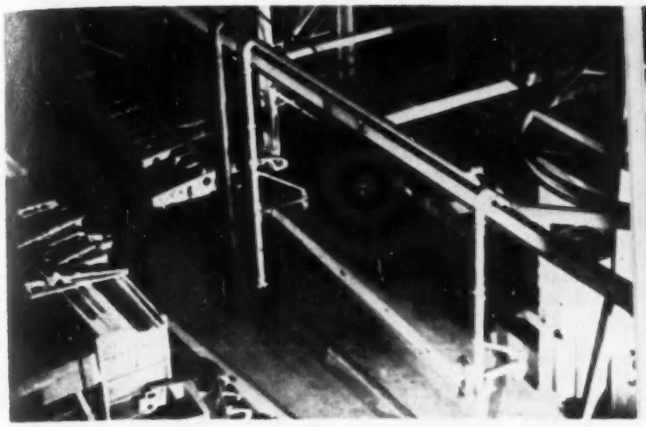

Fig. 3—Wing assembly and production line starts with a spar, shown mounted on a conveyor rack

Fig. 4—Attaching a rib subassembly to a landing gear channel

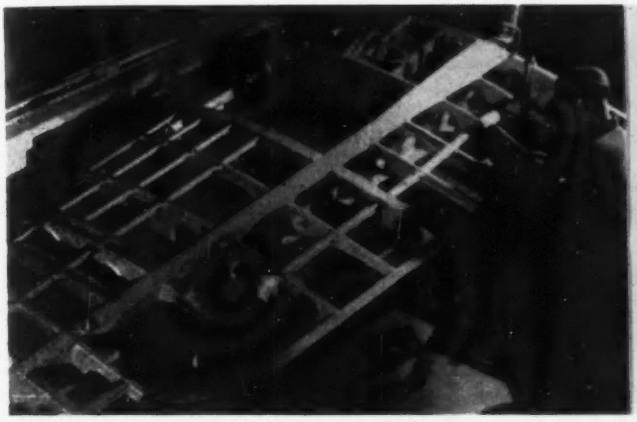

Fig. 5—Assembling ribs and stringers on main and auxiliary spars prior to riveting

Fig. 6—Attaching preformed skins to the frame of the wing

Thin sheet metal was stretched around the portion of the "Master Body" from which the tool was desired. Stiffeners were welded to the sheet to give the tool rigidity. The location of the rivet holes and cut-outs was determined and, after removing the tool from the "Master Body," drill bushings were provided for the rivet holes.

The "Hole Production Method" is suitable for any airframe design, but certain designs are more adaptable to it than others. Modern airframes, based on monocoque design, are ideal for this type of assembly.

Large skins, spars, and longerons are usually the basic elements about which further assembly is made. In the absence of one of these members, a block of detail parts is subassembled and used as the basic structure. The subassembly of the fuselage, shown in Fig. 1, is an illustration of the latter method. The assembled portion has been mounted on a conveyor rack at the beginning of the production line.

Fig. 2 shows the subassembly after it has passed through a number of assembly operations. Because the assembly line, in this instance, was of limited length, the side walls were prefabricated outside the assembly line on automatic riveting machines.

The production of this 15 ft fuselage was accomplished without using any large jigs and fixtures. Working conditions were therefore not disturbed by hindering form jigs or mounting points common to large jigs.

The other case—where a basic element was used

Table 1—Cost Comparison of Production and Tooling for Fighter Wing (Output—500 Sets of Wings per month)

Production Method	Operation Requirement for One Set of Wings				Tooling Requirement for One Set of Wings				
	Single Parts, hr	Minor Assembly and Spar-Assembly, hr	Wing-Assembly Line, hr	Total, hr	Gages and "Master Body," hr	Jigs, Fixtures, etc., and Dies for Single Parts, hr	Wing-Assembly Line, hr	Total, hr	Material, Ton
Assembly line (system: movable large jigs, etc.)	125	210	605	940	(Gages) 16,000	195,000	264,000	475,000	935
Assembly line (system: "Hole Production Method")	115	190 (Includes the spar-assembly line time of 46 hr)	475	780	("Master Body") 11,000	209,000*	95,000	315,000	374

* This figure includes the 68,870 hr for the "Spar-assembly line with standard drill jigs." The ratio for the requirement of tooling is on the average in favor of the "Hole Production Method" as follows:

$$\text{Material weight} = \frac{1}{2.5} \qquad \text{Operation time} = \frac{1}{1.5}$$

as the starting point—is illustrated in Fig. 3. Here the wing assembly and production line started with a spar, shown mounted on a movable rack. It is interesting to note the amazing speed at which the wing took form on the adjoining rack.

The three ribs, which are shown being attached to the landing gear channel in Fig. 4, were subassembled on another line.

Fig. 5 shows the ribs and stringers being assembled or "tacked" with the main and auxiliary spars, prior to riveting them together. The time required for this preliminary assembly or "tacking time" is kept to a minimum with the "Hole Production Method."

Stiffness is given to the frame of the wing by attaching the skin, as shown in Fig. 6. The skins were preformed to facilitate this assembly operation.

A cost comparison of production and tooling for a fighter wing (Output—500 sets of wings per month) is shown in Table 1. Savings in production time, material, and space, effected by using the "Hole Production Method" on a fighter wing, are shown in Table 2.

Outstanding and remarkable savings were made when production reached 500 units per month—33% in production time, 60% in material used, and 40% in production space. This clearly illustrates the obvious advantages of the "Hole Production Method," which is characterized by the following:

1. The assembly line equipment can be of simplest form.
2. There is no need for so-called large, movable fixtures and jigs.
3. The time gained and material saved on operational equipment is considerable.
4. The time required for preliminary assembly or "tacking time" is kept to a minimum.
5. The working conditions are not disturbed by hindering form jigs or mounting points common to large jigs.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

Table 2—"Hole Production Method" on Airframe Assembly Line

Example for a Fighter Wing

Ratio of Tooling of One Set of Fighter Wings

$$\text{Ratio} = \frac{\text{Hole Production Method}}{\text{Normal Production Method}}$$

Production Unit per Month	Production Time	Material	Space Needed When Normal Production Method—100%
50	$\frac{1.2}{1}$	$\frac{1}{1}$	90%
100	$\frac{1}{1}$	$\frac{1}{1.5}$	80%
200	$\frac{1}{1.2}$	$\frac{1}{2}$	70%
500	$\frac{1}{1.5}$	$\frac{1}{2.5}$	60%

Note: The cost of tooling for the "Hole Production Method" is economical starting at 75 units per month.

CAA Developments Provide Safer Aircraft

BASED ON PAPER BY

A. L. Morse, Aircraft Division, Civil Aeronautics Administration

• Paper, "Some Developments for Safer Aircraft," was presented at the SAE Annual Meeting, Detroit, Jan. 8, 1951.

SINCE the old postwar Jennies, we have seen airplanes grow in size, speed, and complexity, and we have seen them become so numerous as to tax the capacity of our airways and airports. This continuing process requires continuous efforts on the part of all concerned to maintain safety. Safety must be designed into the aircraft and its equipment. It requires perfection in aircraft maintenance and operation, and the continued improvement of airports, airways, and aids to navigation and landing. One of the big guns in this battle to maintain safety is development.

Among the various organizations engaged in such work is the Civil Aeronautics Administration Technical Development and Evaluation Center at Indianapolis, Ind. Its activities include the fields of radio, airports, and developments and evaluations involving aircraft components, aircraft equipment, aircraft instrumentation, and safety devices, and are the concern of the Aircraft Division.

The development and evaluation work as conducted by this Division is believed to occupy a separate and distinct field of endeavor, lying between research and actual design. Its activities consist mainly of test programs designed to produce a continuous flow of practical information and design criteria for immediate use by other groups in the formulation of regulations, specifications, and standards in their design of safer aircraft and design of aircraft instruments and accessories specifically required to improve safety, (and in their design of devices for analyzing structural and flight characteristics. Abstract research is avoided, and designing is left to industry.

The need for test results and criteria in such form that they can be applied immediately to specific problems is a governing factor as concerns operating procedures. It requires practical approaches and practical answers. These are obtained by the nature of the tests and through close cooperation and coordination with other aviation organizations. Those organizations participate in the formulation of the CAA programs, and their comments and suggestions influence test procedures. Their representatives spend considerable time in CAA laboratories, and they are closely associated with the work in progress there.

Various phases of the current program are depicted and discussed briefly on the following pages. These are:

1. Fire tests of aircraft installations and aircraft equipment and materials.
2. The development of aircraft instruments and accessories.
3. The development of devices for analyzing structural and flight characteristics.
4. Crash and deceleration tests of aircraft fuel tanks.
5. Tests and studies to improve cockpit visibility.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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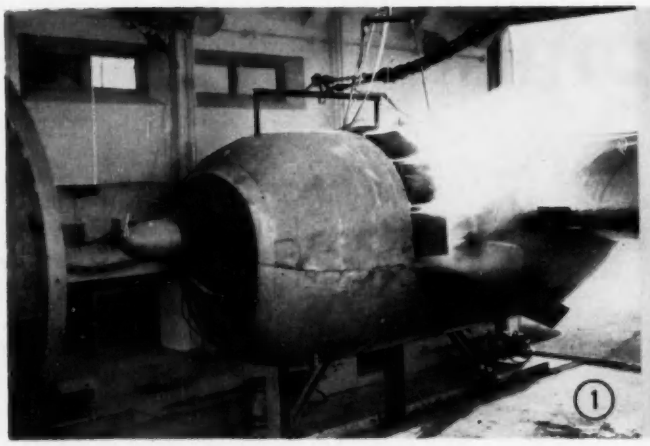
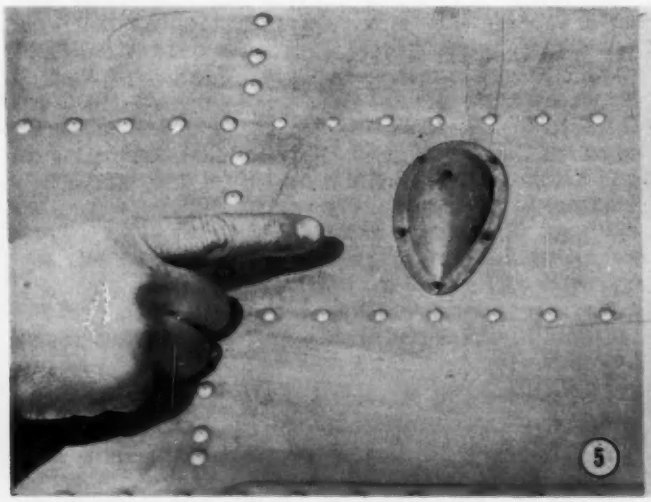
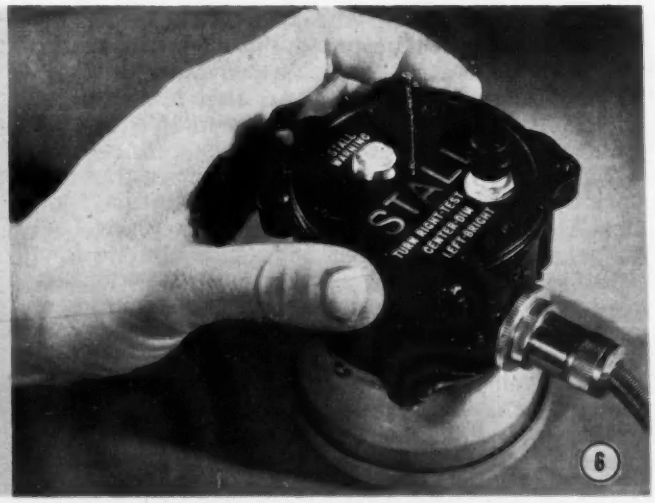
Fire Tests of Aircraft Installations



BOTH piston and jet engine installations are being tested. In reciprocating engine tests, a complete operating engine nacelle arrangement is faced into an air blast to simulate flight conditions. Fires are induced by creating conditions that cause fires in flight and by causing fires through spark ignition of combustible fluids, which are piped into the engine installation. Fig. 1 shows fire test of Constitution engine installation in which an experimental fire extinguishing system is being evaluated. Steel nacelle is used. Fig. 2 shows result of fire test of B-29 installation. Fire resulted from simulated broken oil line. It destroyed aluminum-alloy nacelle structure in less than 20 sec. Laboratory

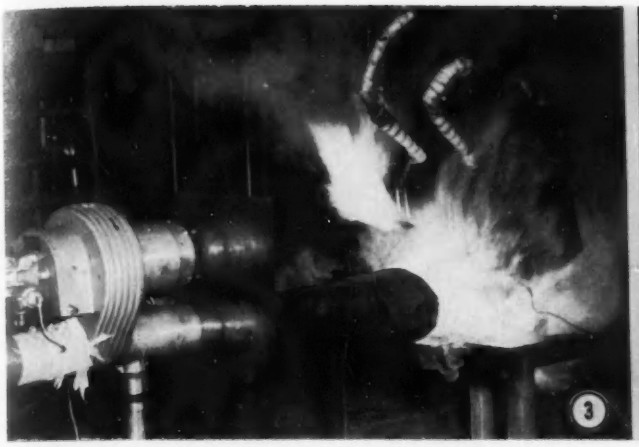
Development of Aircraft





CURRENT developments of instruments and accessories include stall-warning indicators and external lighting. Stall-warning indicators previously developed by Aircraft Division for personal aircraft are now in general use. They are not designed, however, to function when wings are iced up and, therefore, are not suitable for use on transport aircraft. For this purpose, another device, shown in Figs. 5 and 6, has been developed that detects initial appearance of turbulent airflow that occurs on upper surface of wing near trailing edge. Fig. 5 shows stall-warning pickup. In normal flight, air flows through pickup in nose and out top. This cools two legs of electrical bridge circuit to keep it in balance. Turbulence stops airflow, unbalances bridge, and triggers relay. Fig. 6 shows stall-warning instrument. When stall is imminent, horn sounds and word "stall" is lighted. Dimming is

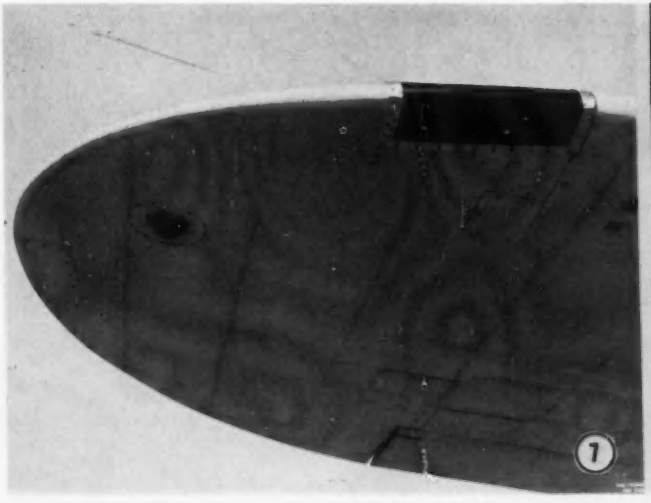
and Aircraft Equipment and Materials

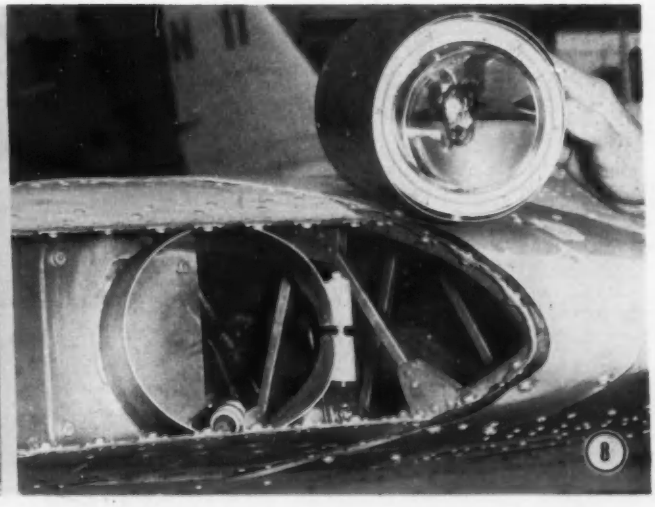


fire tests of equipment and materials largely supplement fire tests of complete engine installations, except they are conducted under precisely controlled conditions, and provide precise and detailed numerical answers. Fig. 3 shows laboratory fire test of steel oil tank. Tank was partly filled with oil and subjected to simulated accessory section fire.

Fig. 4 shows laboratory fire test of aircraft fire detector. The automatic test bench measured the time the detector took to trigger and the time to reset under standardized conditions. Bench tests are also being made of vacuum pump systems, electrical equipment, fire-resistant coatings for aluminum-alloy structures, and the like.

Instruments and Accessories





provided for night operation, and thermal cutout limits horn operation to 5 sec. A test button is also provided. Other developments include high-intensity sweeping and rotating light. Figs. 7 and 8 show installation of light unit that provides high-intensity beam. The 10,000-cp beam (with colored plastic cover shown in Fig. 7) is caused to sweep from straight ahead to 60 deg outboard. Fig. 8 shows disassembly of light. Sealed beam lamp is oscillated from side to side. The 6- by 10-deg beam has maximum intensity of 50,000 cp when clear glass or plastic covers are used. Other high-intensity lights now under development involve cluster of high-intensity rotating lights in small plastic dome, to be mounted on top and bottom of fuselage to give wide degree of coverage.

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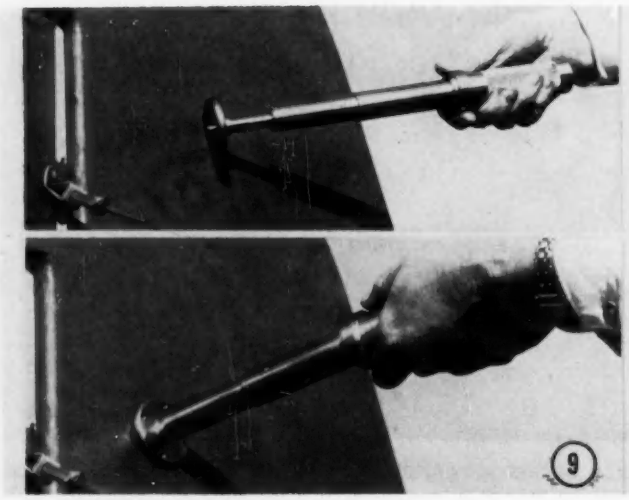
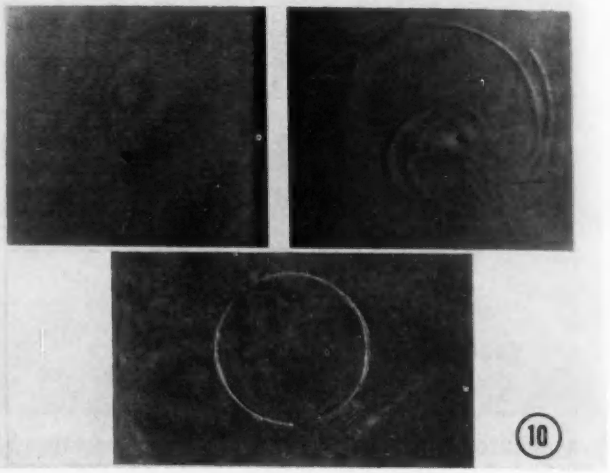
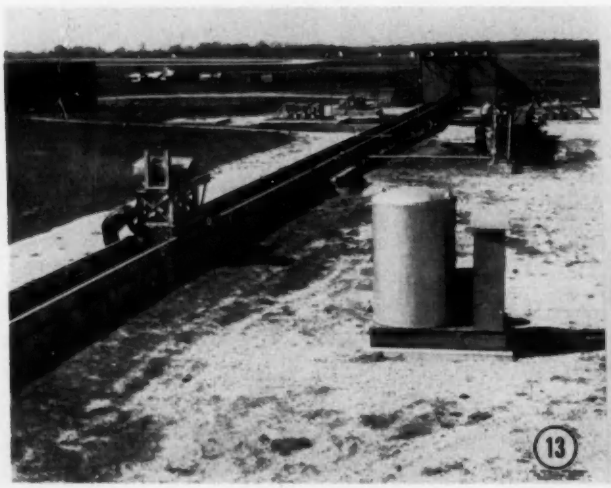
Development of Structura

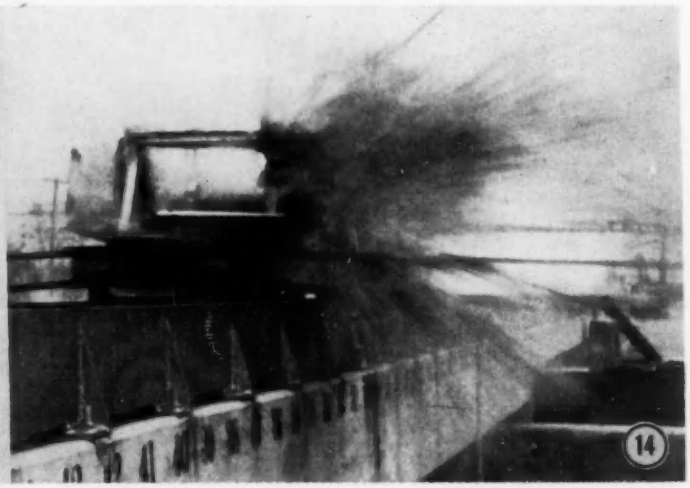




FABRIC tester (Fig. 9) was developed to facilitate inspection of doped fabric coverings of airplanes. It indicates whether doped fabric has deteriorated so as to make it dangerously weak, and whether dope has become embrittled. When pressed against fabric, tester causes small blunt pin to impinge against fabric by automatically controlled hammer blow. Instrument is adjusted so only unairworthy fabric is penetrated. Airworthy fabric is not damaged, and dope is not injured unless it is embrittled. Fig. 10 shows results of use of tester. Circle shows where airworthy fabric and dope were tested 100 times without damage to either fabric or dope. Automatic counting accelerometer was developed

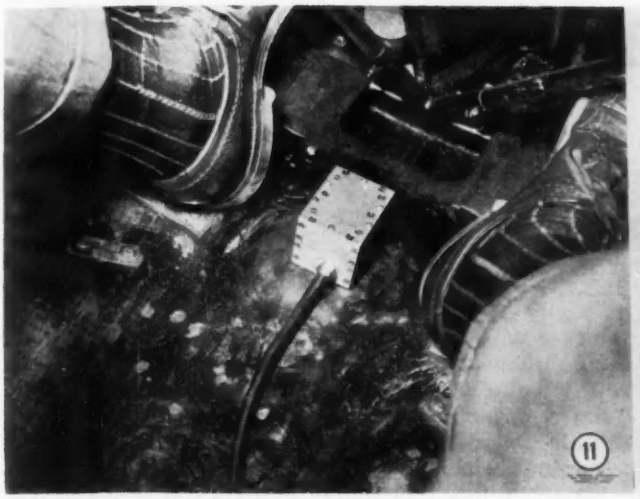
Fuel Tank Crash Tests





FUEL tanks are subjected to crash (Fig. 13) and deceleration (Fig. 14) tests through use of 300-ft track catapult arrangement. A compressed-air-operated aircraft launching catapult supplies speedup power through system of cables leading into track. Cable is attached to pusher car, which is brought up to 100 mph within 100 ft. At this point, pusher car is stopped by brake on track. Tanks are mounted on second car, which continues to coast after pusher car is stopped. Near end of track tank car engages cables of aircraft carrier type arresting gear. With tank fastened to car and filled with water, it can be subjected to decelerations exceeding 20*g*. In crash tests, as shown in Fig. 13, water-filled tank rests on skids, which are attached to car. Tank can be made to leave car and crash into specially arranged obstacles, which simulate some of basic conditions of crash.

and Flight Analysis Devices



to facilitate recording of acceleration loads and shocks actually experienced to make sure that aircraft are designed to withstand such loads safely. Device consists of pickup and counting units. Pickup unit (Fig. 11) contains five weighted leaf-spring elements, each of which is preadjusted to trigger at the desired *g* value. These are connected to corresponding number of electrically operated counters in counting unit, which counts number of times that five different values of *g* are exceeded over specified period of time. It responds to shocks lasting at least 1/50 sec, and counts repeated shocks as they occur at 1/10-sec intervals or greater. Fig. 12 shows location of recording unit.

Cockpit Visibility

COCKPIT visibility program is aimed at improvement in quantity or angles of vision and in quality of vision as affected by optical distortions. One phase involves use of motion picture cameras and mirrors in flight to record directions in which pilots look during various critical maneuvers. Fig. 15 shows camera and mirror arrangement in Boeing Stratocruiser, through which large number of eye motion measurements were obtained. These data are being analyzed, and results, which show where pilots actually look, will be compared with questionnaire data that indicate where pilots would like to look. Directions of vision were obtained by comparing flight movies of pilot's eye's with photographic recording of eye fixations at various predetermined spots in cockpit. Fig. 16 shows portion of motion picture of pilot's eyes during flight, taken through mirror while he made a normal landing.

Wisconsin Plant Operating

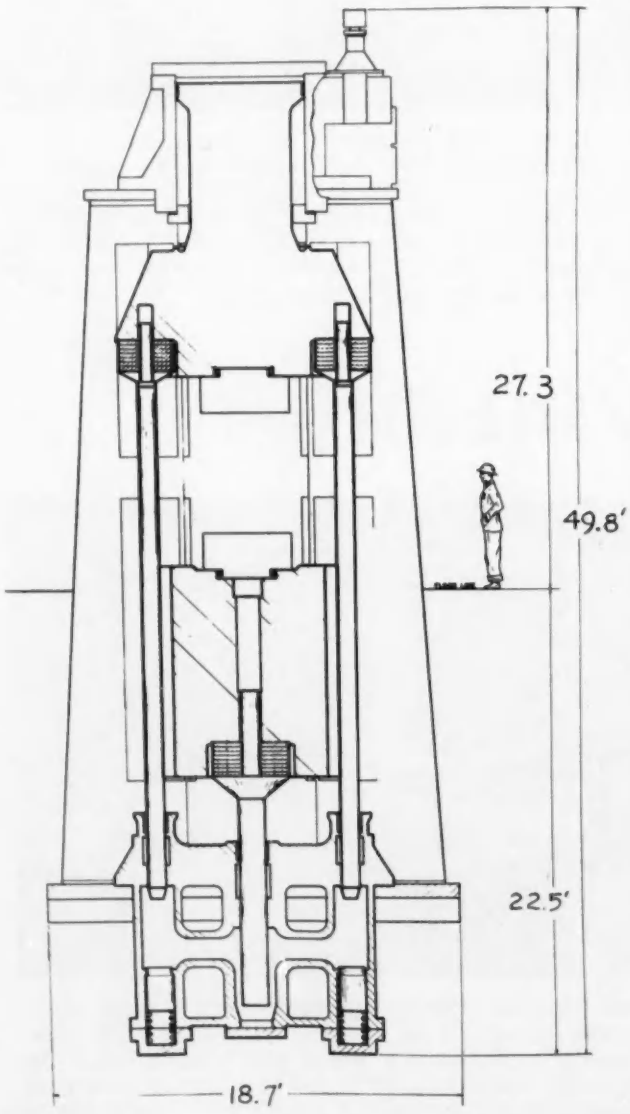


Fig. 1—Schematic section through 80,000 mkg counter-blow drop forging hammer

AFTER World War II, a huge German drop forging hammer of unusual design was brought to this country and set up in the plant of the Ladish Co. at Cudahy, Wisconsin. Auxiliary equipment designed especially for the hammer has enabled its successful operation since early in 1950.

This hammer avoids some of the disadvantages of prevailing American designs. Instead of using a drop and a stationary anvil, the Germans mounted the lower die on a movable ram which reciprocates counter to the upper ram and die. The two rams meet at the center of their combined travel. This allows complete conservation of momentum. No force is lost to the earth through a stationary anvil block and foundation, as happens in conventional designs.

The reciprocating rams have considerably greater energy. German rating of the hammer was 80,000 mkg (88,200 tons). (Ratings refer to weight of reciprocating parts.) Estimates are that it equals in forging performance a conventional hammer of 100,000-lb rating. Very large forgings are possible with the new tool. It has produced totally-enclosed-die contour forgings weighing over 8000 lb each.

Fig. 1 is a schematic drawing of the counter-blow hammer. The base plate weighs approximately 100 tons. Four 32-ft vertical columns guide the rams at the corners. Each column weighs 55 tons. The upper ram weighs 104 tons and the lower 110 tons.

The main piston and upper ram are integral. Attached to the upper ram are two plungers. When the ram drives down, the plungers push into oil cylinders at the base of the tool. Displaced oil forces the lower ram upward by means of a piston-and-cylinder arrangement. Spring-loaded shock valves relieve excessive pressures. Sandwich buffers of steel and rubber reduce inertia loads between the top ram and side plungers. Two stands of buffers cushion the bottom ram on its return stroke.

Primary power comes from the double-acting cylinder in which the main piston operates. When the hammer operator wants to set the hammer in motion, he throws a lever attached to a valve in the system. Fluid pressure is exerted against a servo-piston, which actuates a main balanced-piston valve. This valve controls steam flow into the main cylinder.

Bore of the steam cylinder is 67 in., and piston stroke is 40 in. This called for a substantial boost

Huge Forging Hammer

BASED ON PAPER BY

E. O. Dixon, Vice-President in Charge of Research and Metallurgy, Ladish Co.

• Paper "Developments in Large Closed Die Forging" was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951. This paper was published in full in SAE Quarterly Transactions.

in boiler capacity and storage facilities. So a steam main 14 in. in diameter and 200 ft long was added to the plant facilities.

Some dies were so large that they required a special die sinking mill. This machine was installed in a heavy maintenance shop, where there was adequate crane capacity. Special wagons move the die block from mill to hammer. Die blocks as large as $24 \times 48 \times 154$ in. weighing approximately 50,000 lb have been handled.

The hammer has handled forging billets weighing up to 12,000 lb—too heavy for the usual billet-handling equipment, even in heavy drop-hammer shops. It takes the special manipulator shown in Fig. 2 to charge furnaces, serve billets to the hammer, deliver forgings from hammer to trim press, and transfer from trim press to plant buggy. Capacity of the manipulator is 12,000 lb at an outboard distance of 10 ft.

Center areas of large billets are tender and brittle; too rapid application of furnace heat can cause internal ruptures. Thermal gradients within the billet must be limited.

Furnace experts deemed conventional heating units inadequate in temperature control and scale control. So outsize furnaces specially designed and built for the large billets have a highly accurate constant fuel-air ratio control and an automatic program temperature control. These maintain exact time-temperature cycles for the billets. Temperatures remain uniform throughout the large heating space, and outside air stays out. So well controlled are the furnaces that 20-in. sections weighing over 9000 lb acquire only 1/32-in. scale during heating.

Big billets yield big forgings. At Ladish, big forgings lose their flash in a 3000-ton hydraulic press. Conventional order of punch and trimming dies is reversed for greater ease in providing knock-out cylinders and removal of the forging after trimming.

Large new controllable furnaces cool trimmed forgings so as to avoid development of internal defects.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

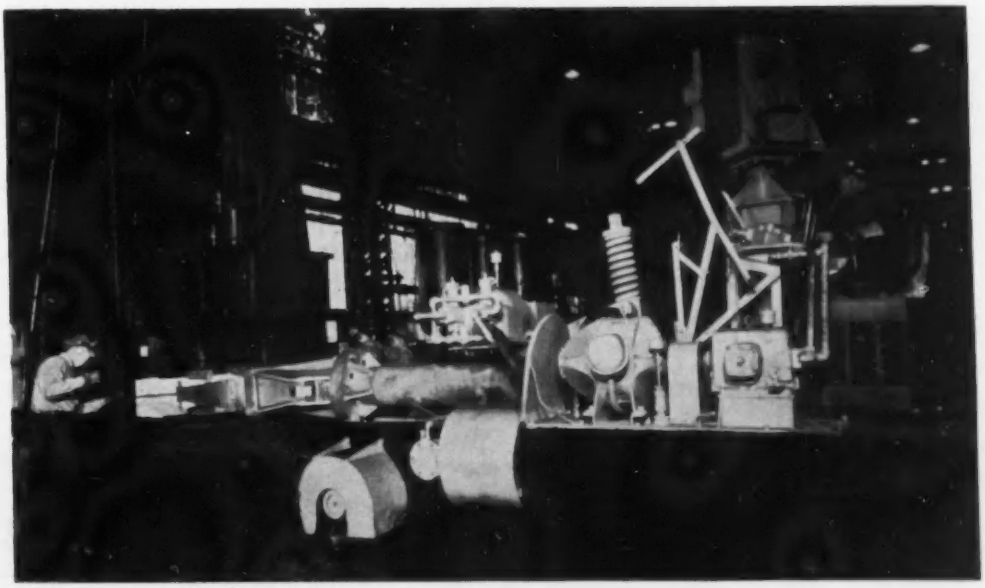


Fig. 2—Floor-operated manipulator of 12,000 lb capacity delivers large forging to trimming press

Operational Stress Data

EXCERPTS FROM PAPER BY

Robert Schilling, General Motors Corp.

• Paper, "Operational Stresses in Automotive Parts," was presented at SAE Annual Meeting, Detroit, Jan. 11, 1951. This paper will be published in full in SAE Quarterly Transactions.

Table 1—Stresses in Suspension Members

		(1) Static Load Stress	(2) Lateral Load Stress	(3) Rut Stress (1) + (2)	(4) Skid Stress 2× (1) − 2× (2)	(5) Overturning Stress 2× (1) − 2.5× (2)	(6) Bump Stress 4× (1)	(7) Brinell Hardness	(8) Yield Strength, psi
Front Wheel Spindle (Steering Knuckle)	Average	10,000	46,000	+56,000 −36,000	72,000	95,000	40,000	240–290	100,000
	High	12,000	51,000	+61,000 −41,000	82,000	107,000	48,000		
Steering Knuckle Support Upper	Average	19,000	19,500	+38,500 − 500	1,000	10,750	76,000	240–290	100,000
	High	20,500	22,000	+42,000 − 2,000	4,000	15,000	81,000		
Lower	Average	10,000	21,000	+31,000 −11,000	22,000	32,500	40,000		
	High	12,500	24,500	+37,000 −12,000	24,000	37,000	50,000		
King Pin	Average	22,000	52,000	+74,000 −30,000	60,000	86,000	88,000	Case 60 Rc	250,000
	High	26,000	58,000	+80,000 −34,000	69,000	98,000	104,000	Core 230 Br	95,000
Rear Axle Shaft	Average	8,000	30,000	+38,000 −22,000	44,000	59,000	32,000	330–360	145,000
	High	11,000	45,000	+52,000 −38,000	75,000	98,000	44,000		
Rear Axle Housing	Average	9,000	2,500	+11,500 − 6,500	13,000	11,750	36,000	Stamping	40,000
	High	12,500	3,500	+16,000 − 9,000	14,500	12,000	40,000		
Lower Wishbone Front Suspension	Stamping High	18,000					35,000	Stamping	40,000
	Forging High	21,000					47,000	207–255	80,000

in Automotive Parts Design

AUTOMOTIVE engineers are often accused of paying little attention to stress analysis in designing parts and components, and of proceeding too much by rules of thumb and by cut and try methods in developing the strength and durability of their products. And it is quite true that the method of finding proper shapes and dimensions for highly stressed parts in automotive engineering makes more use of empirical information and less of analysis than that used in most branches of mechanical engineering. However, when we follow the steps by which we arrive at the proper design and size of our machine parts, we find that they form a sound line of reasoning.

Design practice begins with the observation of failures either in service or in laboratory test of complete machine parts. It leads to an empirical expression relating nominal stresses, calculated in a specific way, to the characteristics of the material.

The stresses calculated by these equations are not intended to represent true stresses, but are simply a measure of the severity of service loading and durability. Such a relation is only applicable to one type of element, manufactured in a certain manner and used in a specific type of service. In spite of these restrictions, this information permits extrapolation to applications which at first sight seem totally different. Many developments in railroad and marine transportation and designs of Ordnance vehicles have been based in passenger car practice and proved highly satisfactory.

In Table 1, for example, are cited nominal stresses on the most important structural members of passenger car suspensions. This group extends over the full range of car sizes and is considered representative.

The loading conditions for which stresses are calculated do not cover all the conditions which a designer must consider. All stresses are nominal stresses as described before, without allowance for stress concentration.

Column (1) gives the stresses due to static load (five-passenger load).

Column (2) gives the stress due to a lateral load equal to 60% of static load applied at the tire-ground contact.

Column (3) Rut stress: $= (1) \pm (2)$. This is the stress produced by bumpy or rutted roads or in fast cornering. It represents a severe loading condition which can be expected less than 100,000 times during the life of a car.

Column (4) Skid stress: $= 2 \times (1) - 2 \times (2)$. This loading consists of double static load, (the whole weight of front or rear end on one side), combined with a lateral load of 60% acting inwards at the tire-ground contact. Although this loading does not represent a realistic road condition, it has been included because of its widespread use in engineering practice.

Column (5) Overturning stress: $= 2 \times (1) - 2.5 \times (2)$. This is presented as an approximation of a more realistic overturning load. It is based on average values of tread and center of gravity height. It also includes consideration of the fact that, due to roll, the center of gravity shifts toward the outside of the turn while the overloaded tire under lateral load distorts and shifts its center of pressure to the inside. The lateral load is assumed partly at the tire-ground contact and partly at the rim.

Column (6) Bump stress = stress caused by 4 × static load at wheel. For most parts, this stress is simply 4 × static load stress, but in some cases it is less because part of the overload is carried by the rubber bumper.

Column (7) The specified Brinell hardness range of the material.

Column (8) The average yield strength of the material corresponding to the lowest hardness in column (7).

The average values are not the average of all cars, but those of one car which is considered representative. The high values show the individual high for that stress; they do not all apply to the same car and hence are not calculated from the stresses shown in columns (1) and (2).

Front wheel spindle (steering knuckle). Shown are bending stresses at the fillet adjacent to the inner bearing. The rut stress runs as high as + 60%, - 40% of yield strength without considering stress concentration. Even with the good surface finish usual at this location, fatigue failure is hence possible. The bump stress is low, but the overturning

Continued on Page 51

Table 2—Torsional Stress in Rear Axle Shafts Under Low Gear Torque

		Stress	Shear Yield Strength
Shear stress at smallest circular section	Average	52,000	83,000
	High	63,000	
Shear stress in spline: Torque divided by section modulus of root circle	Average	55,000	
	High	60,000	

Residual Stresses Can

BASED ON PAPER BY

O. J. Horger, Chief Engineer—Railway Division, Timken Roller Bearing Co.

• Paper, "Stresses Imposed by Processing," was presented at SAE Annual Meeting, Detroit, Jan. 11, 1951. This paper will be published in full in SAE Quarterly Transactions.

RECENT investigations indicate that certain states of residual stress improve the fatigue strength of production parts. This new concept has completely changed the designer's point of view. Attention is now given to retaining thermal and transformation stresses rather than relieving them.

No real science has yet been established concerning the method of producing, measuring, and evaluating the influence of residual stresses on service performance. Those cases where internal stresses are being beneficially applied have evolved through cut and try procedures.

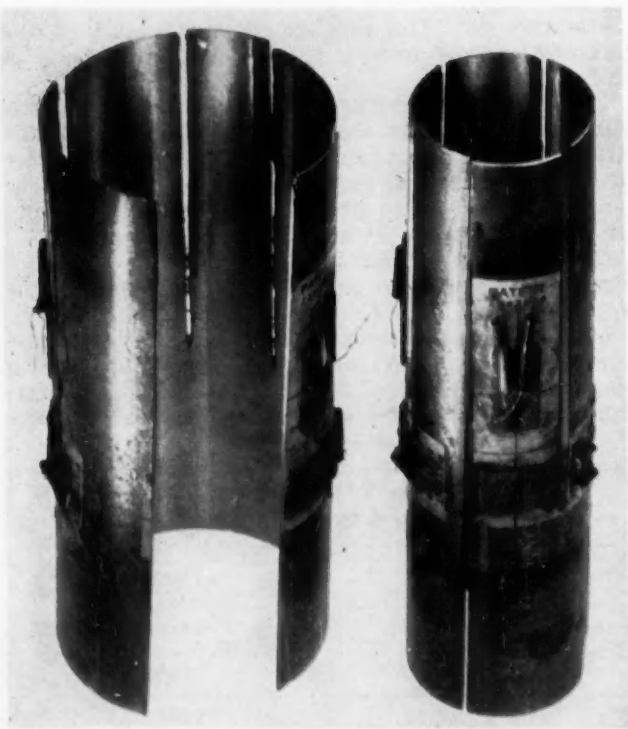


Fig. 1—Sections from rear axle shafts bored-out to determine residual stresses

In the past, little practical advantage was taken of thermal stresses developed when steel was quenched suddenly from a temperature below the lower critical, A_1 point. Results of rotating bending tests on the steel shafts, shown in Table 1, attest to the desirability of such internal stresses.

Two groups of each shaft design—all from the same heat of 1050 steel—were normalized at 1480 F, rough machined to shape, and tempered at 1160 F. A low tempering temperature was used, as most favorable residual stress is lost in the higher tempering ranges. One lot was aircooled and the other was quenched in water. Prior to fatigue testing, the 1-in. fillets on shafts 1 and 2 were machined to remove tool marks and then polished successively with 120, 240, and 320 grit emery.

Rotating bending of the fillet shafts developed fatigue failure near the base of the fillet. The stress concentration present in the other axle, as a result of press fitting the hub member on the shaft about 0.010 in. tight, caused failure a short distance inside the face of the hub.

The residual stresses were determined mechanically by boring out successive layers of metal, supplemented by additional cutting and slitting operations. Resulting plastic and elastic deformations were carefully measured by strain gages cemented to the outer surface of the shafts in a spacing of 120 deg in both longitudinal and circumferential planes, as shown in Fig. 1. Surface compressive stresses of over 40,000 psi for the water-quenched shafts, as compared with nil stresses in the aircooled ones, were calculated from the final length and diameter changes.

These compressive stresses had a marked effect on the endurance limits of the shaft specimens. Water quenching the fillet shafts resulted in a 29% increase in endurance limit over that of similarly designed, normalized shafts. This increase was more than 52% for the press-fit assemblies. Here,

Increase Fatigue Strength

then, is prima facie evidence that favorable initial stresses do improve fatigue strength.

Combinations of thermal and transformation stresses were also found to be desirable. When steel is suddenly quenched from a temperature above the upper critical, A_3 point, three influences act to produce thermal and transformation stresses:

(a) First thermal shrinkage occurring before transformation.

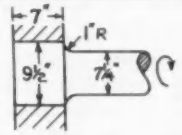
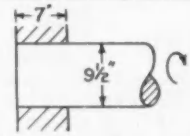
(b) Volume expansion as a result of transformation.

(c) Second thermal shrinkage occurring after transformation.

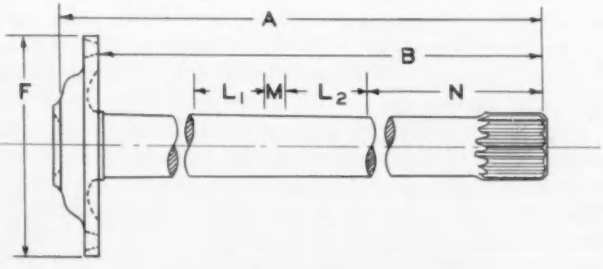
For solid steel cylinders, condition (b) results in tensile stresses at the surface and compressive stresses in the core. Conditions (a) and (c) finally produce a stress pattern opposite to this by causing compression at the surface and tension in the core.

Cooling velocity, carbon content, and specimen

Table 1—Improved Fatigue Strength by Means of Favorable Thermal Stresses Obtained in Quenching from the Tempering Temperature

SHAFT DESIGN	TEST SERIES NO.	HEAT TREATMENT	ENDURANCE LIMIT PSI *
	1	NORM. 1480°F TEMP. 1160°F AIR COOLED	22,500
	2	SAME EXCEPT WATER QUENCH FROM TEMPER	29,000
	3	SAME AS SERIES 1	12,500
	4	SAME AS SERIES 2	GREATER THAN 19,000

* BASED ON 20 MILLION REVOLUTIONS IN SERIES 1 AND 2 AND 85 MILLION IN SERIES 3 AND 4.



D	L1	L2	M	N	A	B	F
1 2/32"	5 1/2"	5 3/8"	1 7/8"	19"	39 3/16"	38 1/16"	6 1/4"
2 3/32"	5 1/16"	5 1/2"	1 7/32"	12"	42 1/16"	40 9/16"	8 3/8"

Fig. 2—Full floating type truck rear axles

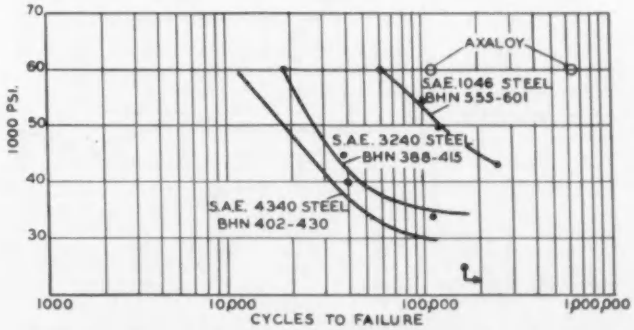


Fig. 3—Repeated stressing of truck drive shafts in reversed torsion

diameter are important factors in determining the order in which these stress formations occur. In high carbon steel, and very highly alloyed materials, the low temperature range of martensite formation often results in transformation taking place after the thermal stress reversal. The transformation stresses then overweigh the small thermal stresses, so that high, undesirable tensile stresses arise at the surface.

Favorable residual thermal and transfomation stresses improved the fatigue strength of the shell-hardened, 1046 steel shafts shown in Fig. 2. After machining and grinding in the as-forged condition, these shafts were austenitized at 1550 F for 20 min, quenched in a 10% caustic solution, straightened from the tempering temperature of 450 F, and then shotpeened.

Two specimens, L_1 and L_2, were taken for residual stress examination. The small shaft specimens closed in both at the slit and the tongues after final cutting operations, indicating residual compressive stresses in the surface layer. The large shafts opened up, exhibiting tensile stresses in the outer layer. (See Fig. 1) This illustrates the effect of diameter on surface residual stresses.

Results of completely reversed torsional fatigue tests on the small-diameter shafts are shown in Fig. 3. It is of considerable practical importance to note the tremendous increase in fatigue strength of the shell-hardened carbon steel shafts, as compared with those approaching a through-hardened condition. (Insufficient tests were made to draw an endurance limit curve for Axaloy, which was designed to give a high surface hardness and a low center hardness.)

Here is a specific case, whereby on the basis of the usual criteria derived from an examination of microstructure and conventional tensile, impact, and fatigue properties, the opinion would be ventured by most engineers that the alloy axles would exhibit equal or better fatigue life than the shell-hardened shafts. Apparently, the favorable residual stress pattern largely accounts for the actual improved fatigue strength of the shell-hardened shafts.

Substantial proof exists that initial stresses level off or fade, due to repeated stressing. (See Fig. 4) In the case of the 0.36% carbon steel, initial longitudinal compressive stresses on the surface of 45,500 psi decreased 87% to 5700 psi after 0.97 million reversals at 48,400 psi bending stress. (This latter stress was slightly below the endurance limit of 49,800 psi and the yield strength of 52,800 psi.) Surface tangential stresses also were reduced considerably and the entire stress distribution through the cross section leveled off.

Even in the presence of surface residual tensile stresses (12% nickel steel), there was a 40% reduction in tangential stress after 1.35 million reversals at a bending stress equal to the endurance limit.

These statements refer to the fading of residual stress in solid specimens. Results shown in Fig. 5 for 0.34% carbon steel tubular specimens are particularly interesting. Here initial surface tensile stresses actually changed into compression after repeated stressing.

Explanation for the loss of initially favorable residual stresses—without loss of fatigue strength—may be sought in the dislocation theory of failure. The old Griffith theory that numerous submicroscopic flaws or cracks exist in materials is currently receiving more and more acceptance. These cracks do not propagate as readily in the presence of compressive residual stresses as when no stresses or tensile stresses are present.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

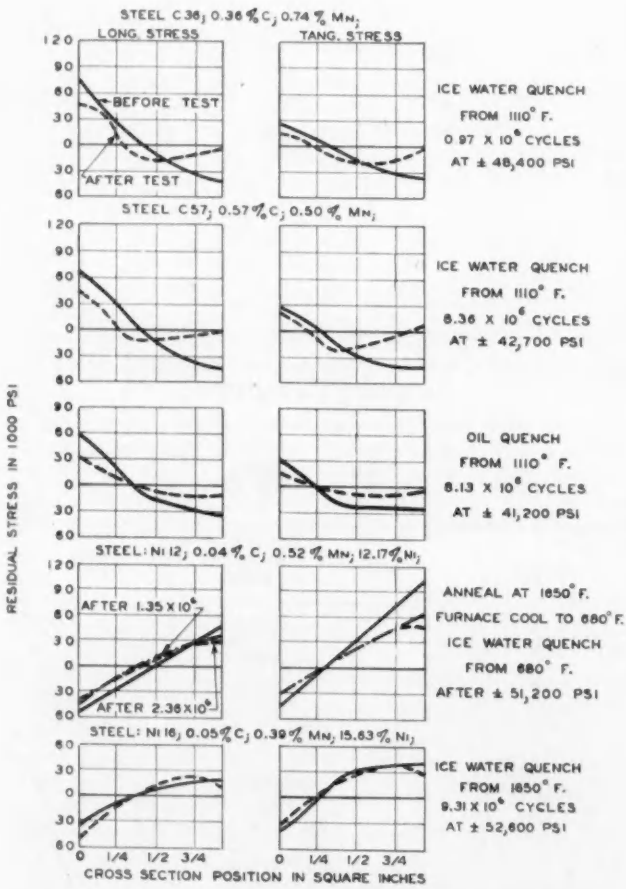

STEEL C36; 0.36% C; 0.74% Mn;
LONG. STRESS
TANG. STRESS
BEFORE TEST
AFTER TEST
ICE WATER QUENCH FROM 1110° F. 0.97 X 10⁶ CYCLES AT ± 48,400 PSI
STEEL C57; 0.57% C; 0.50% Mn;
ICE WATER QUENCH FROM 1110° F. 8.36 X 10⁶ CYCLES AT ± 42,700 PSI
OIL QUENCH FROM 1110° F. 8.13 X 10⁶ CYCLES AT ± 41,200 PSI
STEEL: Ni 12; 0.04% C; 0.52% Mn; 12.17% Ni;
AFTER 1.35 X 10⁶
AFTER 2.36 X 10⁶
ANNEAL AT 1650° F. FURNACE COOL TO 680° F. ICE WATER QUENCH FROM 680° F. AFTER ± 51,200 PSI
STEEL: Ni 16; 0.05% C; 0.39% Mn; 15.63% Ni;
ICE WATER QUENCH FROM 1650° F. 9.31 X 10⁶ CYCLES AT ± 52,600 PSI
RESIDUAL STRESS IN 1000 PSI
CROSS SECTION POSITION IN SQUARE INCHES

Fig. 4—Fading of residual stresses due to repeated stressing

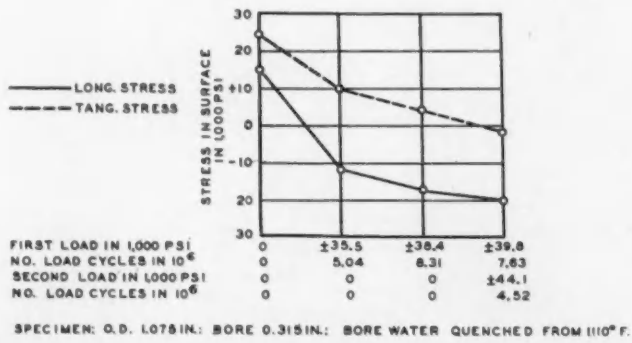

LONG. STRESS
TANG. STRESS
STRESS IN SURFACE IN 1,000 PSI
FIRST LOAD IN 1,000 PSI 0 ±35.5 ±38.4 ±39.8
NO. LOAD CYCLES IN 10⁶ 0 5.04 8.31 7.63
SECOND LOAD IN 1,000 PSI 0 0 0 ±44.1
NO. LOAD CYCLES IN 10⁶ 0 0 0 4.52
SPECIMEN: O.D. 1.075 IN.; BORE 0.315 IN.; BORE WATER QUENCHED FROM 1110° F.

Fig. 5—Influence of repeated stresses on the residual surface stress on hollow cylinder quenched from bore (steel C34: 0.34% C; 0.69% Mn)

Table 1—Rank of Customers of Air Transportation in the U. S. According to C.A.B. Statistics

	U. S. Domestic Trunk Airlines		U. S. International Airlines		U. S. Local Service Airlines	
Traveling Public	$399,000,000	(84%)	$161,000,000	(60%)	$ 8,750,000	(36%)
Shipping Public	47,000,000	(10%)	21,000,000	(8%)	250,000	(1%)
U. S. Post Office	30,000,000	(6%)	84,000,000	(32%)	15,000,000	(63%)
	$476,000,000		$266,000,000		$24,000,000	

Air Transport 1949-1950 -with a view to the future

EXCERPTS FROM PAPER BY

R. Dixon Speas, U. S. Representative, A. V. Roe Canada, Ltd.

• Paper, "Air Transport Developments 1949-1950 and a View to the Future," was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

IN this review and forecast of air transportation developments, five questions appear to be appropriate:

1. What are the customers thinking?
2. How strong is the industry?
3. What new aircraft are being made available?
4. What did SAE contribute in technical paper presentations at National meetings?
5. How does the future look?

Answers to these questions have been developed with cooperative effort of many in the air transportation industry.

What Are The Customers Thinking?

An industry as dependent upon public opinion and good merchandising methods as is air transportation must keep constantly alert as to customer requirements and demands.

The customers of air transportation in this country rank as shown in Table 1 according to Civil Aeronautics Board statistics covering the 12-month period ended June 31, 1950.

In reaching for an answer to current customer requirements and demands, it was decided to enlist the aid of a group of airline business men whose major task it is to know the customer's thinking; namely, the Vice Presidents—Sales of the major airlines. Two questionnaires were prepared and sent to these sales officials with a request that the questions posed be answered, and that names be provided of persistent air travelers and air cargo users. The questionnaires asked what were the three most valuable recent technical developments and what were the three most desirable future technical developments in each of the passenger and cargo air transport fields. The response was most gratifying. Results from the questionnaire were assigned points according to ratings given in the answers:

No. 1 rating = 10 points
No. 2 rating = 5 points
No. 3 rating = 3 points
3 items checked with no preference = 3 points per item
2 items checked with no preference = 5 points per item

By adding up the points for each development the following summaries were prepared.

Results of the questionnaire show answers as fol-

low from 55 persistent airline passenger customers and airline sales officials:

1. What three technical improvements in airline service of the past few years do you, as an airline passenger, consider most important?

	Airline Sales Officials	Airline Passengers	Total
	Points	Points	Points
Faster Aircraft	36	304	340
Pressurized Cabins	23	199	222
Less Flight Delays	18	106	124
Less Flight Cancellations	25	76	101
Improved Airport Terminals	—	69	69
Improved Aircraft Interiors	6	34	40

2. Advances in aeronautical engineering allow substantial improvements to be foreseen in several phases of air transportation. Which of the following possible improvements do you feel should receive most attention by the engineers?

	Airline Sales Officials	Airline Passengers	Total
	Points	Points	Points
Reduced Cancellations and Delays	50	243	293
Higher Speeds	21	146	167
Improved Terminal Facilities	13	144	157
Reduced Noise and Vibration	11	131	142
Roomier Passenger Cabins	8	86	94

One of the most interesting side light results is the consistency between airline sales officials analysis of and actual passenger opinion.

Always of importance in questionnaire results are the "write-ins." Among the most cryptic received were:

Baggage Handling

"Need more efficient luggage handling at terminals."
"Handling of baggage needs improvement."
"Need better handling of baggage—both as to speed and care of same."
"Need better baggage handling." (8 write-ins in addition to above 3)

Food

"Good Food or None."
"Improve Food or Eliminate."
"Improve Meals, Simplify them, or Give them up."

Performance

"Speed is the BIG sizzle—IF 'ON TIME' is the steak."
" 'On Time' pleases more prople than comfort."

Safety

"Need safety devices for fog, night, and storms, etc."
"Safety."
"Safety."

A total of 27 answers was received on the air cargo questionnaire. The answers were mostly from traffic managers controlling shipping orders for large industrial businesses. The 27 answers, therefore, probably offer as much or more market coverage than the 55 passenger answers.

1. What three technical improvements in air cargo service of the past few years do you, as a user of air cargo services, consider most important?

	Airline Sales Officials	Airline Cargo Users	Total
	Points	Points	Points
Decreased Costs—Lower Rates	30	95	125
Improved Ground Handling	11	47	58
Ability Handle Volume Shipments	3	54	57
Faster Aircraft	10	39	49
Improved Pickup and Delivery	13	28	41

2. What improvements do you consider most needed in today's air cargo service?

	Airline Sales Officials	Airline Cargo Users	Total
	Points	Points	Points
Lower Rates	—	66	66
New Cargo Airplane	38	20	58
Better Handling Perishables	—	50	50
Better Ground Handling	5	40	45
Better Tracing Dispatching	10	33	43
Better Schedule Dependability	20	15	35

What appears to be a difference in opinion between airline officials and cargo users probably results from one looking at the result and the other the means. For example, the customer wants lower rates while the airline wants a new cargo airplane, with side comments indicating lower costs as the goal. The customer wants better handling of perishables, while the airline recognizes the need for better schedule dependability and dispatching, both of which would insure better handling of perishables.

Improvements needed in today's air cargo for service, according to Robert S. Burgess, director of air service, Post Office Department, are:

1. Speed in ground handling
2. Speed in flight
3. Stability of schedules

Mr. Burgess says:

"The Post Office Department does not use all-cargo flights for mail except in those cases where no other service is available. Combination passenger-mail-cargo schedules are more reliable, faster, and are not subjected to delays in loading

nd unloading at ports en route as has been experienced with all-cargo flights.

"There was an increase in air parcel post (domestic) for year ending June 30, 1950, over previous year, as follows:

Totals for Fiscal Year 1950

Post Office Revenue	—68%	($13,125,581)
Pieces	—69%	($10,062,732)
Poundage	—71%	($21,683,200)"

How Strong Is The Industry?

Measure of air transport strength can be made on several different bases of comparison:

(a) Numbers of aircraft
(b) Lift
(c) Transportation ability
(d) Operational ability

Judged on any of the above factors, the United States scheduled air transport system has shown, and is showing, increasing strength. Of least significant change is the factor:

(a) Numbers of aircraft

Approximately 1175 aircraft are in scheduled airline service today as compared to 324 in 1940. This increase of 260% is in itself a substantial increase, but unlike "pigs is pigs," "aircraft is not aircraft." Carrying capacity of individual aircraft has so increased in the last 10 years that a more suitable basis of comparison than "numbers" is:

(b) Lift

The "air lift" of 1950 has been increased over 600% in passenger seating capacity over 1940; or based on cargo carrying capacity, the increase is approximately 800%. Incidentally, as of 1940 there was one lone DC–3 in exclusive cargo service. Now a fleet of Cargo DC–4s, C–46s, and DC–3s is today in active cargo service with a carrying capacity over 200 times that of the lone DC–3.

Perhaps a more practical description of the carrying capacity of the 1950 commercial air fleet is to say that in passenger version it could provide a seat for every man, woman, and child of the city of New London, Connecticut.

(c) Transportation ability

Of general acceptance as measures of transportation ability are "ton miles per hour" and "seat miles per hour." These terms include the extremely important factor of speed.

	1940	1950	Percentage Increase
Cargo Ton Miles per Hour	164,500	2,017,000	1100%
Passenger Seat Miles per Hour	1,110,000	10,802,000	875%

(d) Operational ability

Ability to accomplish an assigned mission requires more than numbers of aircraft, seating capacity, and speed. For example, in 1940 there were two ways to go by air from New York to London. One, by a Flying Boat service of such dependence upon sea conditions at intermediate points that an average elapsed time of four days was probably optimistic; and the other, by DC–3 via Laborador, Greenland, Iceland, and Scotland again averaging approximately four days. Today, a 13 hr schedule from New York to London is regularly performed among a total of over 50 weekly trans-atlantic schedules by U. S. commercial airlines. The improved operational ability in other areas is as pronounced.

What New Aircraft Are Available?

The basic measure of an airline's ability to perform lies in the aircraft made available for operation. During the last two years at SAE sessions, new aircraft of this country, England, and Canada have been discussed:

Boeing Stratocruiser

This 60-passenger long-range transport went into volume operation over domestic and international routes of Northwest Airlines; trans-atlantic, transpacific, and South American routes of Pan American Airways; and on the California to Honolulu service of United Air Lines during the last two years.

de Havilland Comet

This, the world's first turbojet transport to fly, is a British-built four engine transport designed to fly up to 40,000 ft at a cruising speed of 490 mph. A British Overseas and Canadian Pacific Airlines have ordered the airplane, production of which is currently underway.

Douglas Super DC–3

By elongation and added power plus numerous design improvements, Douglas gave the famous DC–3 a new lease on life. Capital Airlines has introduced an operating fleet of three of these aircraft over their routes.

Douglas DC–6A

Slick Airways has ordered three of these 30,000 lb cargo transports which were developed by means of elongation, added power and increased structure modifications from the standard DC–6. Slick will incorporate its continental cargo service with the airplane in 1951. The aircraft has also been ordered by the U. S. Air Force and Navy. It and the DC–6B are so designed that turboprop powerplants can be installed in the future.

Douglas DC–6B

A passenger version of the DC–6A, this airplane has been ordered in quantity by American Airlines, United Airlines, and Pan American World Airways. The aircraft will be applied to long haul routes for each of these carriers with the added length of fuselage in most instances being applied to added cargo loads.

Convair 240

Convair has announced two new versions of this most widely used twin engine transport. One, the Convair 248 through increased fuel capacities, higher gross weight and added power, makes possible longer flight range at higher speeds. The second version made its first flight late in 1950 powered by two Alli-

son T-38 turboprop powerplants. Purchased by Allison as a development aircraft, the Convair "Turboliner" will be the first turbine-powered U. S. transport.

Lockheed Super Constellation

By means of 18 ft elongation, added power and increased structure, the Super Constellation will provide added carrying capacity at greater speeds. The airplane has been ordered in quantity by Eastern Air Lines, Trans World Airline, the Air Force, and the Navy. The aircraft has been so designed that installation of turboprops with resulting improved performance can be accomplished at a future date.

Martin 404

A pressurized, elongated, higher power version of the Martin 202, the 404 has been ordered in quantity by Eastern Air Lines and Trans World Airline. Deliveries are scheduled from spring of 1951 to the spring of 1952. The 404 is also proposed in a military version.

A. V. Roe Jetliner

This first American Jet transport first flew in the late summer of 1949 just a few days after the de Havilland Comet captured "World's First." Designed to fly at 30,000 ft with a 4000-ft cabin, the aircraft is intended for routes of up to 1100 miles in length at cruising speeds of approximately 425 mph. The Jetliner is proposed for military application as well as commercial service.

Sikorsky S-55

This 10-passenger helicopter, now in quantity production for military forces, has been ordered by Los Angeles Airways for service on the local routes in and out of Los Angeles. This service, other than temporary airport to downtown operations, will be the first scheduled passenger helicopter service in the U. S.

Vickers Viscount

To this aircraft goes the laurel of first scheduled transport service of a turbine-powered aircraft. In the summer and early fall of 1950, this turboprop aircraft operated in regular scheduled service between London and Paris on British European Airways service. An operating quantity of the aircraft has been ordered by British European Airways for large scale service.

What Did SAE Contribute?

During the last two years, over 5000 miles of technical papers relating to air transport were presented at National meetings of the SAE. The unit of measurement is selected, based on the travel time required for the reviewer to reread the papers to summarize the views presented.

Some general observations appear proper in reviewing the SAE papers of the last two years. One of the most predominate features at the National meetings was continuation of the so-called panel discussions. These related to both design and operating considerations for future transport aircraft as well as covering current operating problems of today's transport aircraft. A continuous theme running throughout the two years of meetings was the conflict of vociferous proponents of turboprops and equally loud-voiced backers of turbojets. Ed Wells of Boeing summed up the situation in the fall meeting of 1950 in Los Angeles when he said "Personally I believe that there are transport jobs for both types to do and the only big mistake we might make is to fail to develop both types continuously and intensively."

A major service of the technical sections of the last two years was to bring out into open forum discussion programs of civil air regulations with respect to this new family of transports. In 1950, the problems were discussed in the forum at Los Angeles, participated in by Rentzel and Haldeman of the Civil Aeronautics Administration, Beall of the Aircraft Manufacturers, aided by Raymond from the floor, and Davies carrying the discussion for the airlines. Military aspects of the problem were discussed by Kuter of the Military Transport Service.

In 1950, Malloy presented a paper outlining "Safety in performance operating rules" which gave some indication of CA requirements for future aircraft, and Haldeman presented a paper at a session of another technical society, both of which undoubtedly bore influence of the 1950 panel discussion. The subject of safety stood high in all papers and was a subject itself in presentations of Wright, Kirchner, and Wuerker. Many new developments were reviewed including flight refueling, flight simulator, new engine developments and new aircraft. Fuels and lubricants held the spotlight, and the subject of safety hydraulic fluids received special attention.

How Does The Future Look?

The following forecasts do not assume general war. It is significant that under two recent extreme threats to world peace, the aircraft which United States commercial air transport built were of vital importance. Neither the Berlin Airlift nor the Pacific Airlift could have been effectively accomplished without the aircraft, organization, and "know-how" created by United States commercial airlines. Continued efforts to establish and maintain full peace in the world require a strong and strengthened air transport system. These forecasts indicate a growing air transport strength:

1. Substantial improvements in schedule regularity and dependability will result during the next five years from activation of the CAA sponsored navigation improvement project presently emerging from the planning stage.

2. Any basically new transport aircraft introduced into transport service during the next 15 years will be powered by turbine powerplants (helicopters excepted).

3. Turbine powered aircraft will be introduced into transport service of the United States within the next two years.

4. Commercial air strength (up approximately 1000% in 1950 from 1940) will continue to increase through 1952 at a rate equal to or greater than any other commercial phase of national strength.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

FUEL VOLATILITY——

Trends and Problems

BASED ON PAPER BY

W. M. Holaday and D. P. Heath, Socony-Vacuum Laboratories

• Paper, "Motor Fuel Volatility Trends," was presented at the SAE Annual Meeting, Detroit, Jan. 9, 1951. This paper will be published in full in SAE Quarterly Transactions.

IN this paper the authors give their opinions about the volatility problems of our present and future motor fuel. To aid in establishing these problems, they review the relationships between fuel volatility and engine performance; they chart past volatility trends; and they predict future volatility trends.

They then discuss the probable volatility problems of the future and define the responsibilities of both the automotive and the petroleum industries in solving them.

BEFORE discussing the relationships between fuel volatility and engine performance, we must, first, define volatility and, second, decide which criteria of engine performance are affected by fuel volatility.

The common yardsticks that we use for measuring volatility in our everyday work are Reid vapor pressure and ASTM distillation. These yardsticks have been used alone and in various combinations to correlate with engine performance. For example, it is generally recognized that Reid vapor pressure correlates with vapor lock, and the 90% point on the ASTM distillation curve correlates with crankcase oil dilution. There are dozens of such relationships —some very simple and others quite complex. To simplify the job of relating fuel volatility to engine performance, the first step is to divide volatility into three classes. These classes—or more properly, parameters—are as follows:

• Initial volatility, which is a measure of the tendency of the first 20% of a fuel to vaporize. It is measured by the Reid vapor pressure and the first part of the ASTM distillation curve.

• Average volatility, which is a measure of the tendency of the major part of a fuel to vaporize. It is measured by the 50% point of the ASTM distillation curve.

• Final volatility, which is a measure of the tendency of all of a fuel to vaporize. It is measured by the 90% of the ASTM distillation curve.

These parameters are not perfect, for there are undoubtedly exceptions, but they are entirely adequate for the present discussion.

The various criteria of engine performance that are affected by fuel volatility—as discussed in this paper—are: vapor lock, evaporation loss, warmup, stalling, starting, acceleration, fuel economy, crankcase oil dilution, engine cleanliness.

This list includes all the important criteria, although there are others.

Now it is possible to relate the fuel volatility parameters to the engine performance criteria, as shown in Table 1.

Of these criteria, vapor lock, evaporation loss, warmup, and stalling will be discussed in detail. The others will be mentioned only briefly.

Vapor Lock

Vapor lock occurs when the fuel flow to the engine is restricted by the formation of vapor in the fuel system. If you have ever experienced vapor lock, you know that it can completely immobilize an automobile for what seems to be an agonizingly long time. We like to believe that, through the years, improvements have been made in the utility and reliability of the automobile as well as in its appearance. Vapor lock is one item, though, where progress has been very slow. The vapor-locking characteristics of prewar and postwar cars are compared in Fig. 1. Here the results of vapor-locking tests conducted by the CFR in 1939, 1940, and 1946 are shown. The coordinates are—across the bottom —per cent of cars vapor locking and—up the side—Reid vapor pressure of the fuels. The conditions of

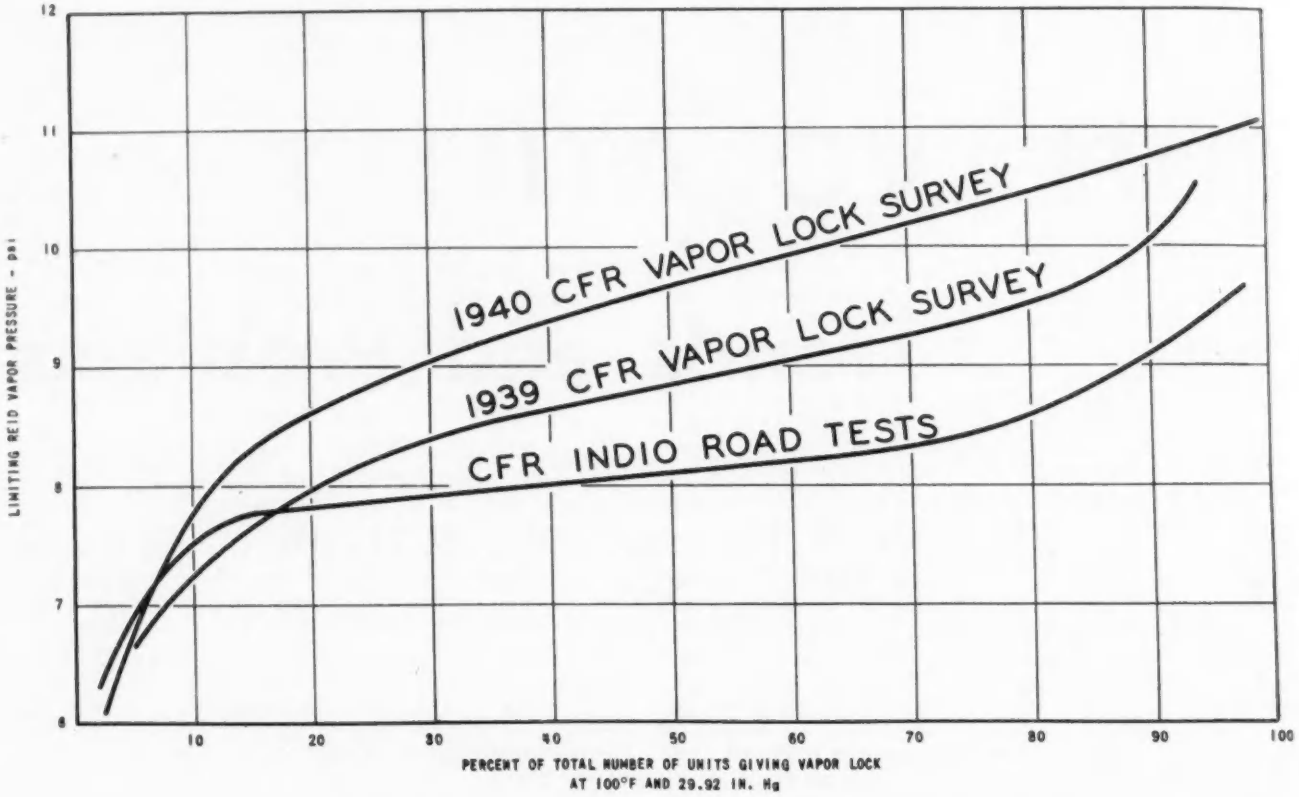


Fig. 1—Limiting Reid vapor pressure for cars tested in CFR surveys

test were 100 F ambient air temperature and sea-level pressure.

You will note that in both the 1939 and 1940 cars fuels of higher vapor pressure could be used than in the 1946 cars. Admittedly, the 1946 data are not as complete as the 1939 and 1940 data; but a definite trend toward increased vapor locking is noted. This trend should be of concern to the automotive industry because, as we will point out later, economic forces indicate that gasolines should be of higher vapor pressure.

Table 1—Relation of Engine Performance Criteria to Volatility Parameters

	Volatility Parameters		
	Initial Volatility	Average Volatility	Final Volatility
Engine Performance Criteria	1. Vapor lock	1. Warmup	1. Fuel economy
	2. Starting	2. Stalling	2. Crankcase oil dilution
	3. Evaporation loss	3. Acceleration	3. Engine cleanliness

Table 2—Fuel Characteristics

	High Volatility Fuel	Average Volatility Fuel
Reid Vapor Pressure, psi	8.4	8.8
ASTM Distillation, F		
10% Evaporated	129	134
50% Evaporated	161	221
90% Evaporated	212	320

Evaporation Loss

Evaporation losses in the automotive fuel system have not been a major importance in the past. However, because these losses are potentially of importance and because very few data on their magnitude were available, they are treated in considerable detail in the paper. Space doesn't permit describing the test programs conducted to evaluate fuel evaporation losses from passenger-car gasoline tanks and carburetors; however, the results can be presented.

The gasoline tank evaporation loss test results are summarized in Fig. 2. Here, the vapor pressure of the fuel at the temperature in the tank is plotted against the loss in gallons per year per car. It is readily apparent that the losses are higher for tanks that are not kept filled. Quarter-full tanks cause higher losses than half-full tanks.

A typical year-round average true vapor pressure of gasoline is about 5 psi. At this vapor pressure the losses are 2.7 gal per year from a half-full tank and 4.2 gal per year from a quarter-full tank. While these losses appear to be insignificant, the total for all of our passenger cars amount to 2,500,000 bbl of gasoline per year.

The carburetor loss data are summarized in Fig. 3. Here the true vapor pressure of the fuel at the temperature in the carburetor bowl is plotted against the per cent of fuel evaporated. In this case some

if the evaporated fuel can be efficiently used if it is vented into the air horn, as is common practice. The amount of this vapor that is used efficiently depends upon the mixture ratio prevailing. It has been estimated that—for an average figure—half of the vapor vented to the carburetor is burned efficiently.

The fuel temperature in a carburetor bowl averages about 35 F above the ambient air temperature. Under these conditions the carburetor loss is about 0.3%, or 2 gal per year per car. However, the loss scale is logarithmic and, as the carburetor fuel temperature rises, the evaporation loss increases rapidly. If the temperature rise becomes 65 F instead of 35 F above the ambient air, the average loss would be 27 gal per year instead of 2 gal per year. The newer, more streamlined cars have a distinct tendency toward higher underhood temperatures. If not controlled, these temperatures will create a carburetor loss as well as a vapor-lock problem.

Warmup

Next, warmup will be considered. The warmup period is the time between starting the engine and obtaining smooth performance. This period should not be overly long and engine operation should not be overly rough during this period. Fuel volatility is an important factor in warmup. Fig. 4 presents a rather complex relationship between 10% point, 90% point, 50% point, ambient temperature, and miles to warmup. The miles to warmup scale can be varied by the conditions of test. For this particular scale 3 miles is considered satisfactory warmup. Fuels giving a warmup of over 3 miles are considered unsatisfactory.

While the relationship presented here is somewhat complex, the major variable is the 50% point. The 10% and the 90% points have secondary effects on warmup. Obviously, therefore, fuels of high 90% points can give satisfactory warmup, provided the 50% points are properly controlled.

Stalling

The fourth engine criterion to be considered is stalling. Engine stalling or failure of the engine to idle is usually caused by carburetor or ignition system malfunctioning—but it can also be caused by overly volatile fuels.

The refrigerating effect, when highly volatile fuels vaporize in the carburetor, can cause ice formation under the proper conditions. When this ice formation interferes with the idle bleed, the engine will not idle properly.

In order to evaluate the magnitude of this icing problem, the Socony-Vacuum Laboratories undertook a road test program starting last summer. The characteristics of the fuels used in this program are shown in Table 2. One of these fuels was highly

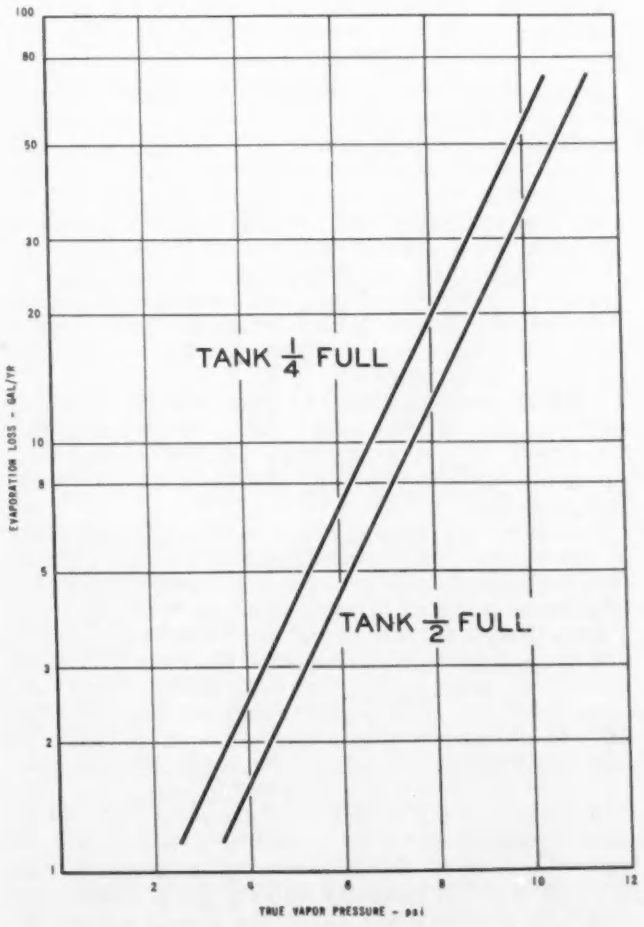


Fig. 2—Evaporation losses from passenger-car gasoline tanks

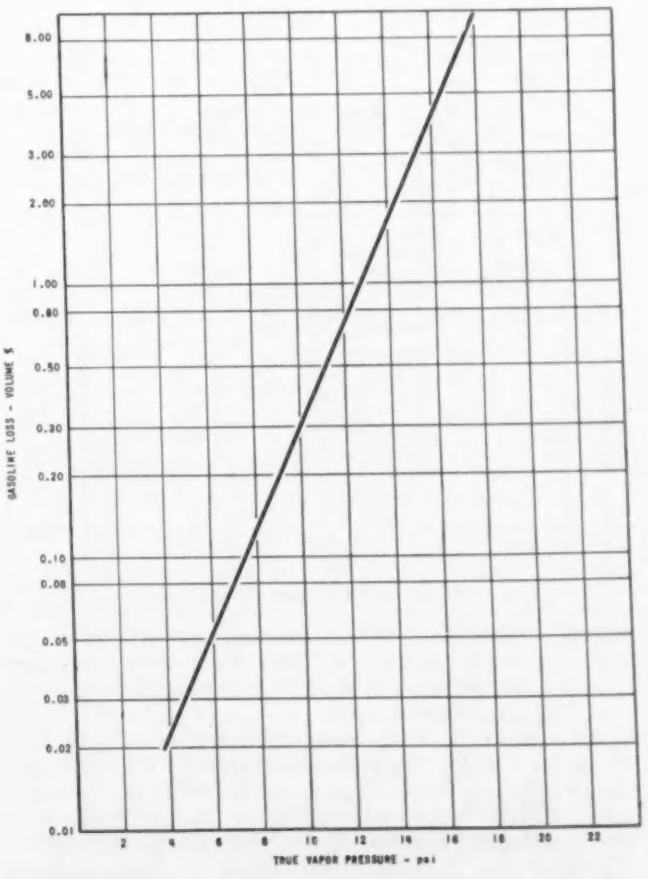


Fig. 3—Effect of vapor pressure upon carburetor evaporation losses

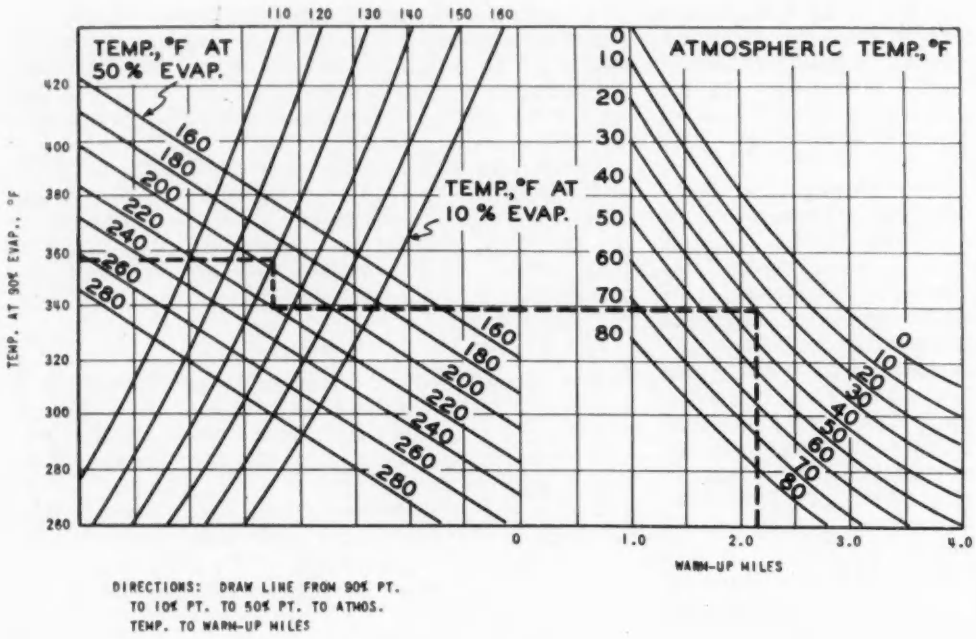

TEMP., °F AT 50 % EVAP.
TEMP., °F AT 10 % EVAP.
ATMOSPHERIC TEMP., °F
TEMP. AT 90% EVAP., °F
WARM-UP MILES
DIRECTIONS: DRAW LINE FROM 90% PT. TO 10% PT. TO 50% PT. TO ATMOS. TEMP. TO WARM-UP MILES

Fig. 4—Relation of ASTM distillation characteristics to warmup

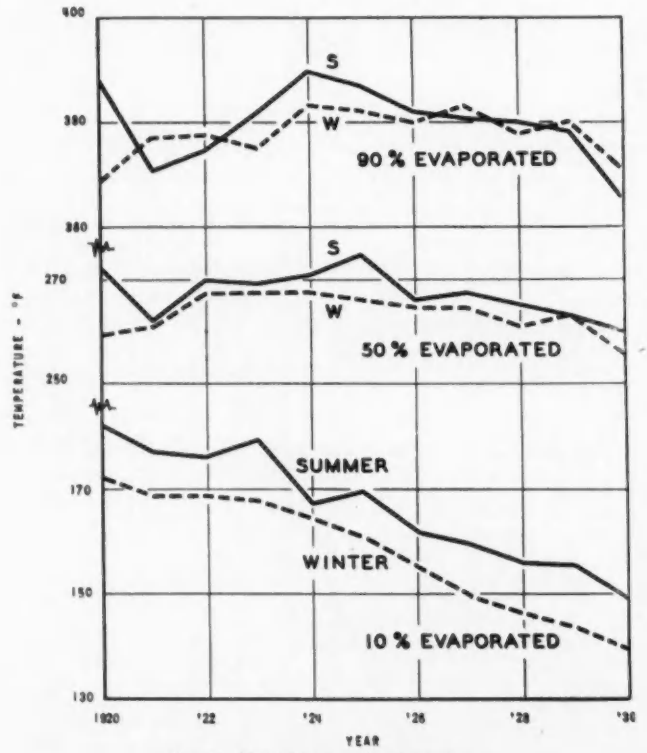


Fig. 5—Volatility trends of gasoline

volatile while the other was of normal volatility. The vapor pressures of both fuels were normal. The major differences were in the 50 and 90% point distillation temperatures.

Twenty-seven cars were operated alternately on these two fuels. In a rather short time 21 of these cars experienced stalling troubles with the volatile fuel, which were attributed to carburetor icing. None of the 27 cars exhibited the same characteristic with the normal fuel. Fuels of intermediate volatility were then incorporated in the test program. Each increase in the 50 and 90% points of the fuels reduced the number of cars giving difficulty. While the exact relationship between volatility and stalling has not been established, modest increases in 50 and 90% points of the volatile fuel eliminates a substantial part of the stalling difficulties.

Other Criteria

Next, let's consider starting. This time of year most people realize that an automobile can be very contrary on a cold morning. However, fuel quality has only a minor influence on ease of cold starting. The mechanical condition of the engine and its electrical system are of primary importance along with the use of the lubricant of right viscosity.

Next, let's discuss acceleration. In this case we mean the rate of acceleration after the engine is warmed up. Under these conditions, fuel volatility has only a very minor effect on the accelerating ability of an automobile.

Fuel economy is another factor that is influenced only slightly by fuel volatility. The possible differences in fuel economy between extremes of commercially available motor gasolines are generally less than 5%.

Crankcase oil dilution was somewhat of a problem 30 years ago. Improvements in crankcase ventilation and the production of more voltaile fuels have made crankcase oil dilution a minor problem.

Concerning engine cleanliness, the formation of piston lacquer and crankcase oil sludges can be partly attributed to fuel characteristics. Road tests have indicated that properly refined fuels of high 90% points cause slight increases in piston and crankcase deposits. The differences found, however, are not of appreciable significance.

We have now covered one phase of the background information on volatility required for an understanding of the problem. That phase is the relation between volatility and engine performance. The next phase is the volatility trends which we have witnessed in the past.

In Fig. 5 we have a little ancient history. Here the average volatility characteristics of gasolines in the twenties are shown. During this period the 50 and 90% points were relatively constant. The level of 50 and 90% points was quite high—20 to 40 F above present levels. During this era the 10% point decreased steadily. This resulted from the increase in thermal cracking, which increased the production of butanes.

In Fig. 6 the volatility trends of average gasolines are shown for the modern era. You will note that in the prewar period there was a steady decrease in the 50% and 90% points. This trend is a result of the increase in octane number during the same period. As will be discussed later, cutting the distillation range is one method of increasing the octane number of thermally cracked and straight-run gasolines. In the postwar era, these trends have been reversed because of processing changes.

In charting the past volatility trends, we have dealt with averages. Averages are useful, but for many purposes the deviations from the average are equally important. The designers of carburetors, automatic chokes, and intake manifolds need to know the range of gasoline volatility which their devices will be called upon to handle. Fig. 7 gives an indication of the magnitude of the deviations in volatility. Here, the distributions of the 10%, 50%, and 90% points for regular-grade summer gasolines are shown.

The major portion of the 50% points cover a range of 40 F. This distribution does not change much with season of the year except that the whole pattern shifts slightly.

The major portion of the 90% points covers a range of about 50 F. Again this pattern tends to shift with seasons without much change in shape.

The distribution of the 10% points covers a narrower range, the major part of the data falling in a 25 F range.

By narrowing these ranges in the volatility of its gasolines, the petroleum industry could contribute to the development of better fuel induction systems.

Future Gasolines

Now that the past volatility trends have been reviewed, let's take a look at the factors which will influence the volatility characteristics of our future gasolines.

The first of these factors is refinery processing trends. The major development in this field is the increased usage of catalytic processes. As is well known, catalytic cracking capacity was expanded very rapidly during the war. Since the end of the war, the capacity has doubled and further large increases in catalytic cracking capacity are expected.

Catalytic reforming processes are now being commercialized. A number of installations have already been made and rapid expansions in the capacity of this new type of process are anticipated.

Both catalytic cracking and catalytic reforming produce gasolines which have high antiknock quality throughout their boiling range. This characteristic is shown in Fig. 8. Here, the octane number of typical refinery gasoline stocks is shown as a function of the 90% point of the gasoline. The octane numbers of straight run, thermally cracked, and thermally reformed gasolines decrease with increasing 90% point. For this reason, the trend in the 50

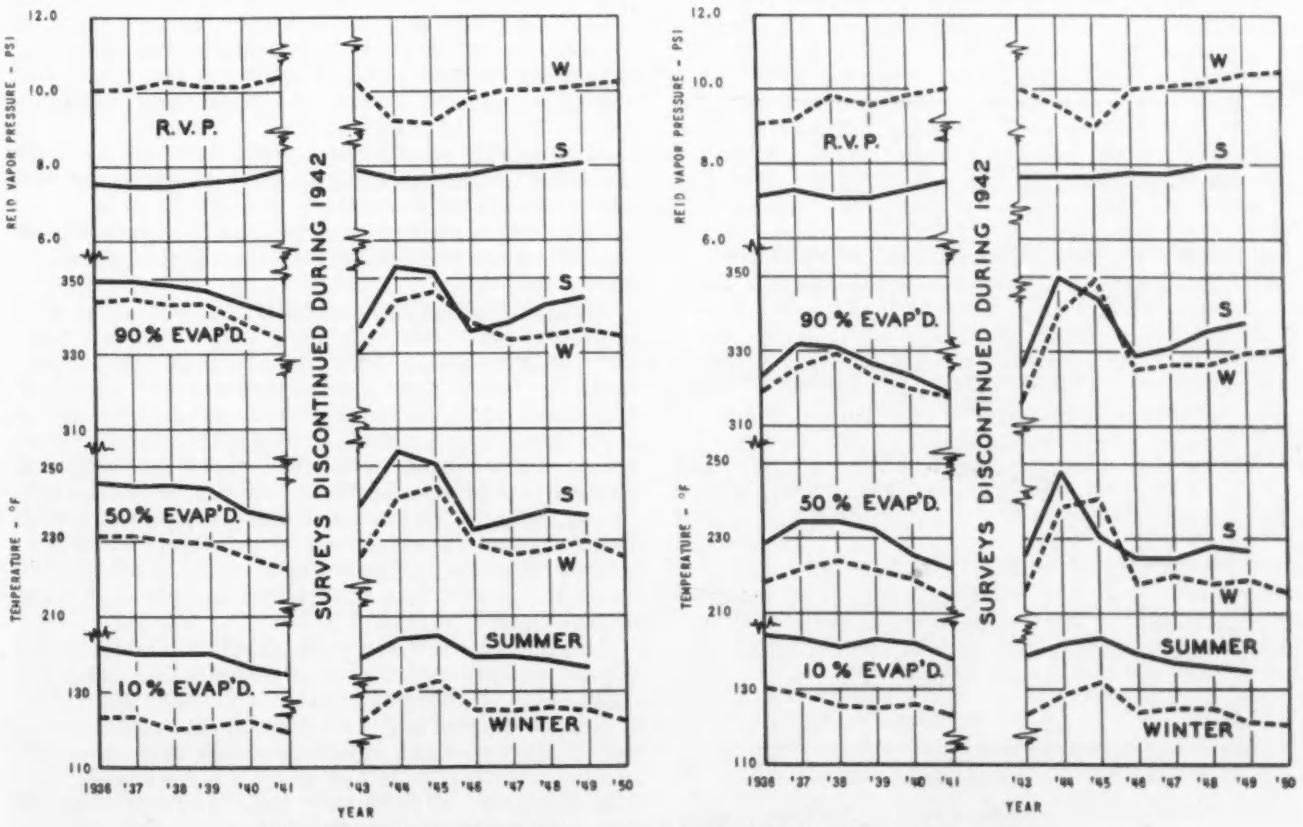


Fig. 6—Volatility trends of (left) regular-grade and (right) premium-grade gasolines

and 90% points of gasolines produced in the prewar period was toward lower levels to help keep pace with rising octane numbers.

On the other hand, with catalytic cracking and catalytic reforming, the octane number is practically independent of the 90% point. Hence, after a refiner puts in one of these catalytic units, he wants to make gasoline of high 90% point to get the maximum production for his large investment.

Another trend influencing the volatility of future gasolines is the increasing availability of volatile materials. These materials come from two sources —the refinery and the oil and gas fields.

In the refinery, the production of butanes increases as the severity of cracking and reforming is increased to raise octane-number levels. Thus, as octane levels go up, butane production also goes up.

The gas produced in the oil and gas fields contains so-called condensables, which are removed before the gas is marketed. These condensables are largely volatile gasoline fractions. Increasing use of natural gas and increased conservation operations in crude oil fields will cause the production of these volatile materials to rise at a faster rate than gasoline production.

If the increased yield of volatile materials is put in motor gasoline, vapor pressures will go up. An alternate procedure, of course, is to convert the butanes to low-vapor-pressure gasoline by alkylation or polymerization. However, these processes cause a product volume loss as well as a reduction in octane number—both of which are undesirable. The loss in volume amounts to about 22% and the loss in octane number is about 5 to 10 units. Admittedly, increased evaporation losses will occur if all of the butanes are put in motor gasoline. Nevertheless, the best overall utilization of butane is obtained by their incorporation directly into motor gasoline.

These future trends in volatility can be summarized as follows. We will have higher vapor pressures and higher 90% points. Higher vapor pressures will result from the increased production of volatile gasoline fractions and higher 90% points will result from changes in the types of refinery processes.

Having established these trends, let's take a look at the problems which these trends may create.

First, the trend toward the distribution of fuels of higher vapor pressure will intensify the vapor-lock problem and may create an evaporation loss problem.

Higher 90% points alone would not be of much concern; but, coupled with cooler intake manifolds, they may create a warmup problem.

The responsibility for solving these problems lies, of course, with both the automotive and petroleum industries.

First, the automotive industry should attempt to overcome the vapor-lock problem. As we have pointed out, fuels of higher vapor pressure increase both the yield and the octane number of motor gasolines. The conversion of butane fractions to gasoline of average boiling range by refinery processing is not attractive because of the losses in both volume and octane numbers. Hence, it is desirable to have vehicles which can utilize gasolines of higher vapor pressure as efficiently as possible. The automotive industry, then, should attempt to design and to build vehicles that will permit the use of fuels of higher vapor pressure.

A number of steps can be taken to increase the vapor-pressure tolerances of vehicles. Among the most obvious of these steps are (1) shielding fuel system components from heat, (2) the use of gasoline tanks and caps of the pressure type, and (3) the use of a fuel pump at or in the fuel tank.

It should be obvious that the timing of steps to increase the vapor-pressure tolerance of cars is im-

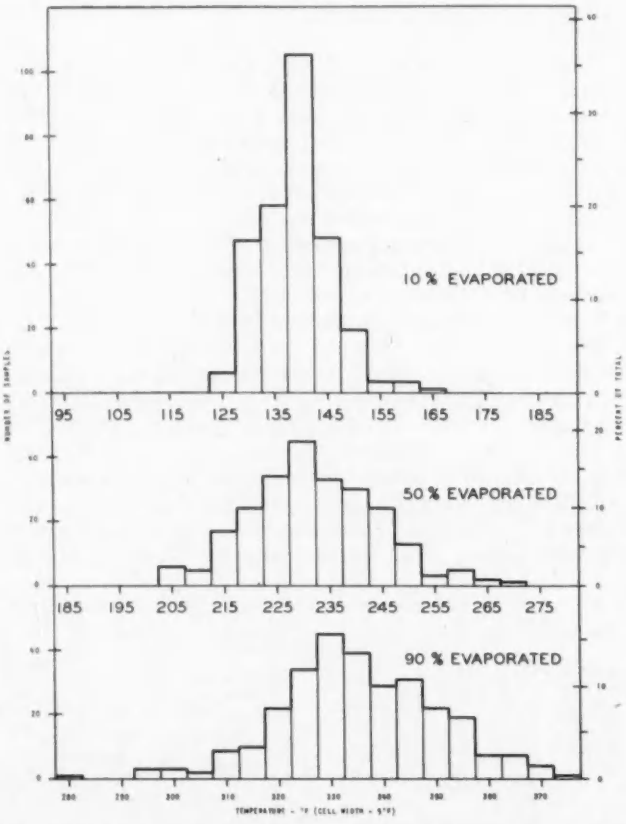


Fig. 7—Distillation characteristics of regular-grade summer gasolines

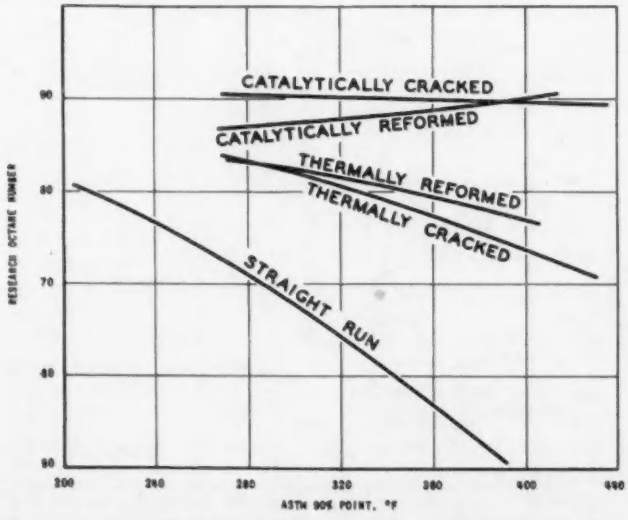


Fig. 8—Effect of ASTM 90% distillation point on clear Research octane number of typical gasoline components

portant. About 10 years is required to replace all of the vehicles in service. Hence, improvements should be made immediately to accommodate the gasolines of higher vapor pressure, which will be sold several years from now.

If suitable steps are not taken, the present margin of safety from vapor lock will be reduced and the motoring public will become vapor-lock conscious. This is a condition that would not be relished by automotive or petroleum industries.

The warmup problem may not materialize, but if it does, its solution by the design route appears to be the most practical. The use of fuels of higher 90% points will also facilitate the production of fuels of higher octane number and will help conserve our petroleum resources.

The solution of either the vapor-lock problem or the warmup problem by the petroleum industry would result in the permanent loss of some of our petroleum resources and would require increased refinery processing, both of which would tend to make gasoline cost more.

Up to this point the burden of utilizing the fuels of higher vapor pressure and higher 90% point has been placed solely on the automotive industry. However, the petroleum industry has a definite responsibility to face in order to facilitate the automotive design changes which are required. The production and marketing in a given area of gasolines which cover a wide range of volatility place an undue load on the designer of the fuel induction system. Consequently, the petroleum industry should attempt to produce and market gasolines which do not deviate widely from the average characteristics—particularly with regard to initial volatility in the summer and average volatility throughout the year. Greater uniformity in fuel volatility characteristics should permit the design of cars and engines having even greater reliability and higher performance than the present-day standards.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publication Department. Price: 25¢ to members, 50¢ to nonmembers.)

Operational Stress Data in Automotive Parts Design

Continued from Page 37

stress reaches yield strength. Evidently this part must be designed for both static and fatigue failure.

Steering knuckle support. Bending stresses in the highest stressed sections, both above and below the kingpin boss, are given. The rut stresses are lower than for the wheel spindle, but in view of the poorer surface and less careful control of fillets, fatigue is still possible. Bump stresses and overturning stresses are safely below yield strength.

King pin. The stress is calculated for the section at the edge of the boss in which the pin is clamped; the load is assumed concentrated in the center of the bushing in which the pin rotates. The calculated stresses are hence higher than may be expected. The rut stress appears to be well below the fatigue durability of the case, and no overload stress approaches its yield point. Considering the usual case thickness of 0.040 to 0.050 in. on a diameter of one inch, the stress at the junction of case and core is about 90% of the listed stress. Fatigue failure at this location is unlikely since this subsurface material has high fatigue durability, but there is only a small margin against yielding of the case under overturning or bump stress.

Rear axle shaft. Listed is the highest bending stress either at the wheel bearing or in the tapered portion. No stress is in excess of 68% yield stress and, compared to the front wheel spindle, the rut stress appears low in relation to the higher yield strength of the material. However, it must be considered that the rear end may be loaded well beyond five-passenger load, and that the axle shaft, due to its rotation, is subject to more stress reversals than any part of the front suspension, so it must be designed primarily for resistance to fatigue failure.

Rear axle housing. Since the rut stresses do not reverse, the danger from fatigue is small, but bump stress approaches yield strength of material.

Lower wishbone, front suspension. High values for one design using stamped arms and one design using forged arms are shown. Fatigue loading is not calculated since it appears unimportant; the bump stress is near yield strength for the stamped part, but well below for the forged construction.

Another critical stress on axle shafts is represented by the torsion stress at the inner end, either in the splined section or in a circular section next to the splines. These stresses are listed in Table 2. It can be seen that the highest nominal stress reaches 76% of shear yield strength. In view of the stress concentration present, fatigue is possible even if stress reversal (in reverse gear) is infrequent.

The stress data shown in Table 1 and Table 2 check well with the service experience on these parts. That is the best reason we can have for using such calculations, although the loading conditions selected may appear arbitrary. Our aim in formulating a stress calculation must be first to predict service failure and only secondly to derive it in a rational manner. If we can do both, so much the better.

In applying this information to new designs, we must never forget its source. Although the stress equations look like generally valid relations, they fit only a narrow range of service conditions, of sizes and shapes, and of manufacturing processes. Extrapolation beyond that range is possible, but it requires care and caution.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members; 50¢ to nonmembers.)

Equal Wheel Torque

Freedom from Spin, have been

Design Goals of

IN designing differentials, the ultimate target has been to develop a mechanical device which will distribute torque equally to the two driven wheels which are being differentiated, under any condition of relative motion as dictated by ground speed, but never permitting torque to be applied to any one wheel in excess of the available traction without causing both wheels to slip simultaneously.

The conventional differential meets this requirement in one respect in that it differentiates between the wheels equally under all conditions of relative road speed. However, it permits one wheel to spin and can give torque only to the non-spinning wheel equal to the traction factor of the spinning wheel plus the slight internal friction of the differential itself.

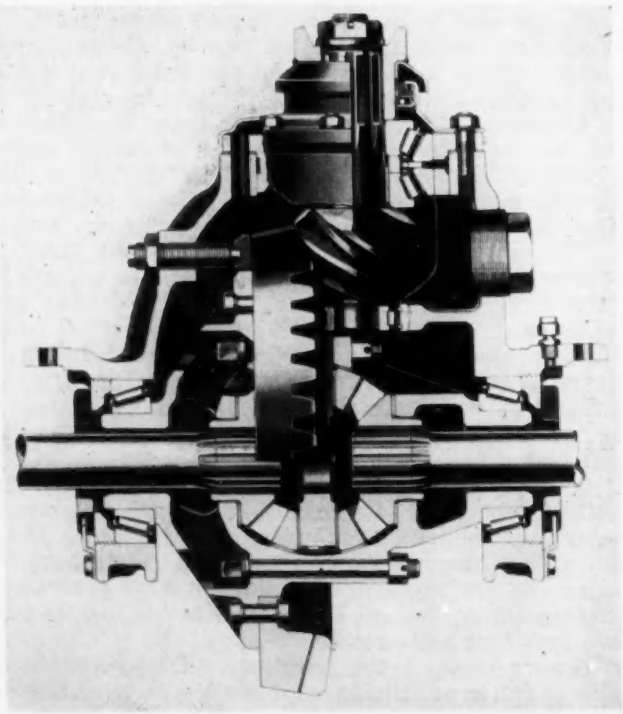


Fig. 1—Modern rear-axle drive unit for commercial vehicles

To provide a differential free from stalling, engineers have devised many ingenious devices other than the conventional differential. But the conventional type still predominates in automotive vehicles.

The commercial-vehicle differential assembly shown in Fig. 1 consists of a differential spider having four trunnions, four differential pinions, four pinion thrust washers, two differential side gears, and two side gear thrust washers. All these parts are contained in a differential case or housing consisting of two halves held together by bolts. The large half of the differential case has a flange to which the main drive gear (hypoid in this instance) is fastened. An exploded view of the internal parts of this differential assembly is shown in Fig. 2. The design shown has replaceable bronze bushings in the bores of the differential pinions to provide a good bearing on the differential spider trunnions.

Differentials for passenger car use generally have two differential pinions instead of four. With this construction the differential spider becomes a straight pin and the differential case is made in one piece instead of two. This construction has the advantage of fewer parts. But it must be larger than the equivalent four-pinion differential, since only half as many tooth contacts are available for power transmission.

Differentials have been built using spur gears instead of bevel gears. For a given torque capacity these differentials tend to be narrower in overall width but larger in diameter than the bevel-gear type. Because this greater diameter tends to restrict ground clearance, the spur-type differential is now seldom used in conventional single-reduction axles. However, in some special applications where diameter is not critical, the narrower overall width

Automotive Differentials

EXCERPTS FROM PAPER BY

L. R. Buckendale and L. G. Boughner

Vice-President in Charge of Engineering, Experimental Engineer
The Timken-Detroit Axle Company

• Paper "The Automotive Differential" was presented at the SAE Annual Meeting, Detroit, Jan. 8, 1951. This paper will be published in full in SAE Quarterly Transactions.

of the spur-type unit makes its use desirable. In the typical-spur type differential, there are two spur side gears and six spur pinions. The pinions act in pairs, each meshing with one other pinion and with one side gear.

Referring to Fig. 1, power from the vehicle propeller shaft enters the axle through the drive pinion, passes to the ring gear and differential cases, is transferred by the cases through the differential spider to the differential pinion, goes from the pinions to the side gears, and is delivered by the side gears to the axle shafts. Each bevel pinion functions as a balance lever between the two side gears.

Thus, if the differential gearing is of the constant-velocity type (involute tooth form or equivalent), any torque impressed on the differential cases will always divide equally between the two side gears, dividing output torque equally between the two axle shafts and wheels. This equalization of torque will be maintained regardless of whether the vehicle travels a route that is straight, curved, rough, or flat. During straight-ahead travel on flat surfaces, the whole differential assembly will revolve as a unit, the differential pinions remaining stationary on their trunnions. Both side gears will turn at the same angular velocity, and both road wheels will revolve at the same speed.

When one road wheel must turn faster than the other, as when rounding curves or traversing uneven surfaces, the differential pinions will revolve on their trunnions. One wheel will thus be permitted to speed up and the other to slow down an equal amount, but equal torque distribution to the two wheels will be maintained. The change in speed of the two road wheels will always be such that their average speed will equal the speed of the differential case assembly.

Wide variations in tractive effort can exist between driving wheels of an automotive vehicle. If the tractive effort which can be developed by the two wheels is unequal, the total tractive effort available for vehicle propulsion will be twice that available at the wheel having the least traction since the conventional automotive differential always divides torque equally between the two wheels.

In an extreme case where one wheel rests on ice while the other rests on dry pavement, a relatively low wheel torque will cause the wheel on ice to spin. This same low torque will be all that is available at the wheel on dry pavement, and will probably be insufficient to move the vehicle. The vehicle will stall.

This possibility of stalling is the one big disadvantage of the conventional bevel-gear differential. Another disadvantage is that if one wheel hits a bump hard enough to leave the road it will accelerate, and when it again contacts the road tire scuffing will result. These are serious shortcomings. Nevertheless, the conventional differential has been so satisfactory in other respects that it continues predominant in the automotive field.

Since the conventional differential always divides torque equally, the maximum tractive effort available for propulsion will be twice that of the wheel having least traction. From this it is obvious that tractive effort can be increased if means can be found to increase the torque needed to turn the wheel having least traction. This can be done by applying the wheel brakes.

In Fig. 3, maximum tractive effort obtainable is plotted against coefficient of friction at the wheel having least traction. The wheel having partial traction can produce tractive effort equal to its load times its coefficient of friction as shown by line OA. Both wheels together can normally produce twice this amount as shown by line OB. If this amount of tractive effort is insufficient to move the vehicle, it will be stalled.

If the rear wheel brakes are sufficiently applied, the wheel having full traction can be made to develop its maximum tractive effort as shown by line CA. Adding to this the tractive effort of the other wheel, line OA, we obtain line CB. This is the total maximum tractive effort which it is possible to de-

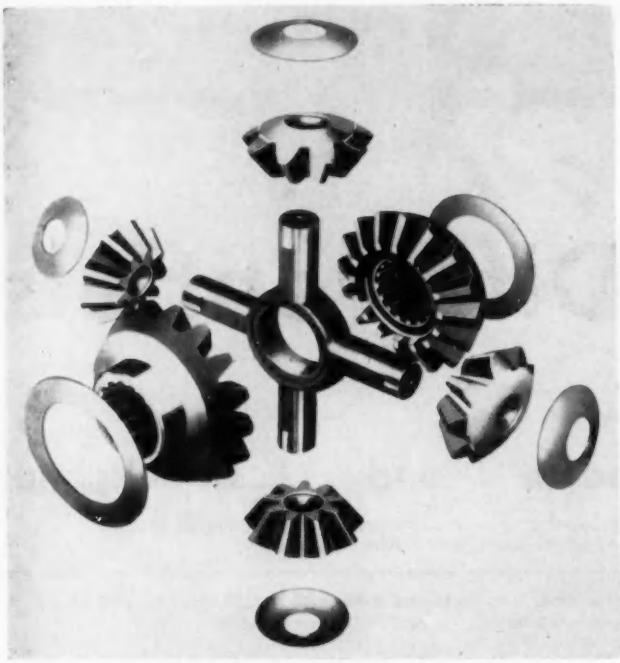


Fig. 2—Exploded view of parts of differential shown in Fig. 1

velop when one wheel has partial traction. The gain in tractive effort obtained by brake application is the difference in height between lines CB and OB.

In the above example, note that brakes were applied to the rear wheels only. If brakes are applied to all four wheels, the torque required to turn the front non-driving wheels will subtract from the torque available for vehicle propulsion. Thus, with 25% braking on the front, maximum obtainable tractive effort will drop from line CB to line EB.

On vehicles so built that the hand-brake lever actuates the rear wheel brakes directly, use of the hand brake is the easiest method of applying brakes to increase tractive effort. On vehicles with propeller-shaft brakes, a limiting valve which will entirely cut out the front brakes plus a hand-operated control valve for the rear brakes is most convenient, since the feet are thus left free for accelerator-pedal and clutch-pedal operation.

Brake application is an effective method of preventing stalling and wheel spinning, but is awkward for the operator, produces brake wear, uses additional engine power, and encourages engine stalling.

Three other general approaches to the problem of achieving the optimum in differentials are:

1. Differential With Friction Added—Adding friction to the differential mechanism to prevent wheel spinning does away with equal torque distribution under different conditions of relative road speed. But all of the differentials which add friction or, in other words, use a torque bias due solely to friction, have this limitation: The torque distribution is not equal when the road relative wheel speeds become different.

2. Differentials Of The Locking Type—Several differentials have been so designed that they can be locked either manually or automatically when one driving wheel has low traction, thus making differential action impossible. Wheel spinning and stalling are thereby prevented and the full traction available at both driving wheels can be utilized.

Locking up the differential at the whim of the driver is, of course, a stop gap because it requires mechanical skill to determine just when and how the differential should be locked and to remember when to unlock it.

3. Differentials Of The Torque Bias Type—Some differentials have been so designed that when one driving wheel has low traction, more torque is automatically supplied to the other wheel. Wheel spinning and stalling are thus minimized, or eliminated entirely.

The varying-leverage type has limitations in that the bias that can be created, due to leverage, is limited by mechanical considerations. Using a variable leverage combined with increased internal friction helps prevent wheel spinning but, depending on the amount of bias, detracts from equal distribution of torque when the wheel speeds differ.

So far, no one has come up with one answer that satisfies all of the demands of differential rear-axle driving under all of the conditions in which the driving wheels may operate. Maybe what we are looking for is a mechanical or electronic brain.

A differential mechanism called upon to distribute torque between axles of a bogie, or between a front drive axle and the pair of axles in a bogie, becomes a still more difficult problem. The same limitations apply; that is, if a conventional differential is used, the drive is limited to the traction ability of the wheel having the least traction. If there are differences in tire size, putting a torque bias in may result in one axle's doing most of the driving and supplying the torque necessary to overcome the torque bias. Unlocking the axle which runs faster by means of a declutching-type differential results in the remaining axle doing all the work. To this problem there has not as yet been a complete answer. It probably would require another variety of the same mechanical or electronic brain.

Following are examples of the three non-conventional types of differentials.

(The complete paper from which these excerpts are taken treats also cam-type torque-bias differentials, including the Mack Power Divider; the Multi-Pull positive-clutch differential; the No-Spin differential; and the Bush differential, which divides torque unequally. The paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

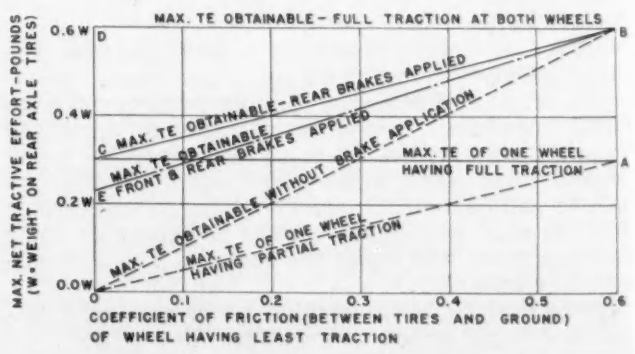
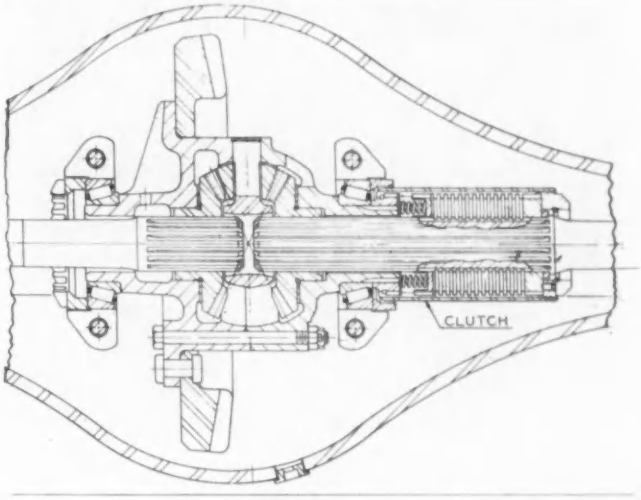


Fig. 3—Tractive effort obtainable when driving wheels have unequal friction coefficients

Differential with Friction Clutch

Timken Differential Friction Clutch is applied to one side of a conventional truck differential. Alternate steel and bronze clutch discs are used. The steel discs are splined to the axle shaft. The bronze discs are splined to a sleeve, which is in turn splined to an extension of the differential case. Twelve helical springs apply a fixed axial pressure to the discs.

For travel which requires no differential action, the assembly revolves as a solid unit. However, if one wheel encounters low traction and tries to spin, this tendency is resisted by friction forces at the clutch plates. Because of these friction forces, greater torque is required to turn the wheel having low traction. This greater torque is made available at the other wheel.

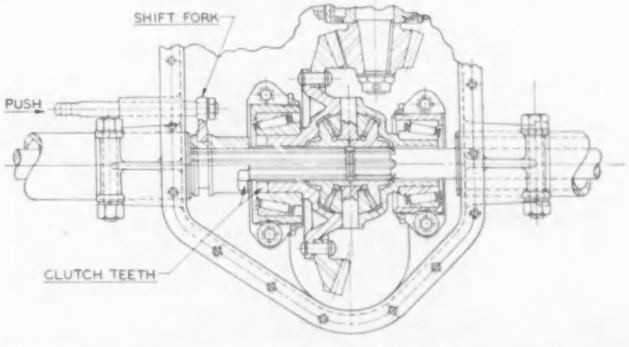


Locking Type of Differential

Differential Lock for Bevel-Gear Differential was used on some early motor trucks. In this particular design, a shift fork operated by rod or cable from the driver's seat actuates a clutch collar. The collar engages clutch teeth on one end of the differential case asembly.

When the truck loses traction, engaging the clutch collar couples the case to one axle shaft and its side gear.

This locks the differential.

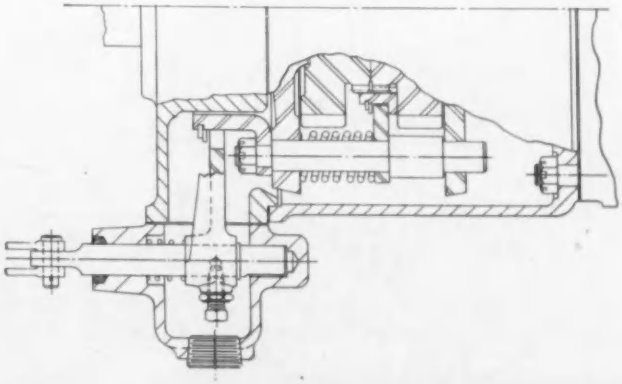


Differential Lock for Spur-Gear Differential is applied to an inter-axle differential. It is actuated by the driver from the truck cab.

When the truck loses traction, the driver actuates the cab control. This causes the shift fork to move the clutch collar, thereby locking the differential by coupling the two spur-type side gears together.

This movement also compresses three helical springs which surround three pins on which the shifting mechanism slides.

Releasing the cab control causes the three springs to return the shift collar to the normal disengaged position.



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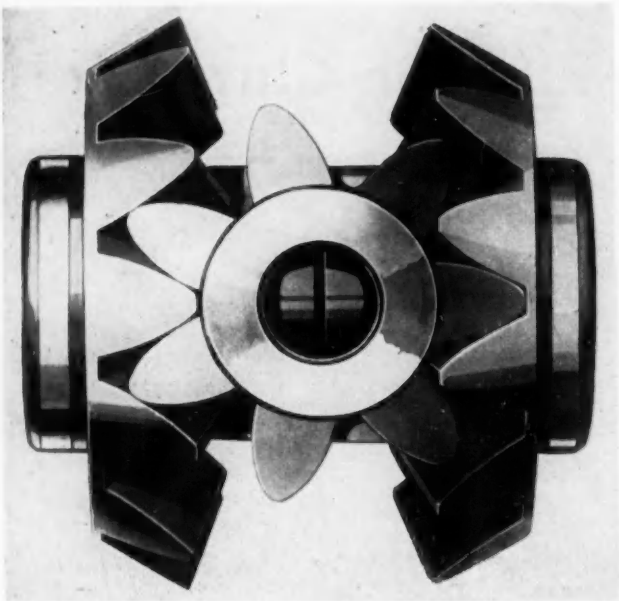
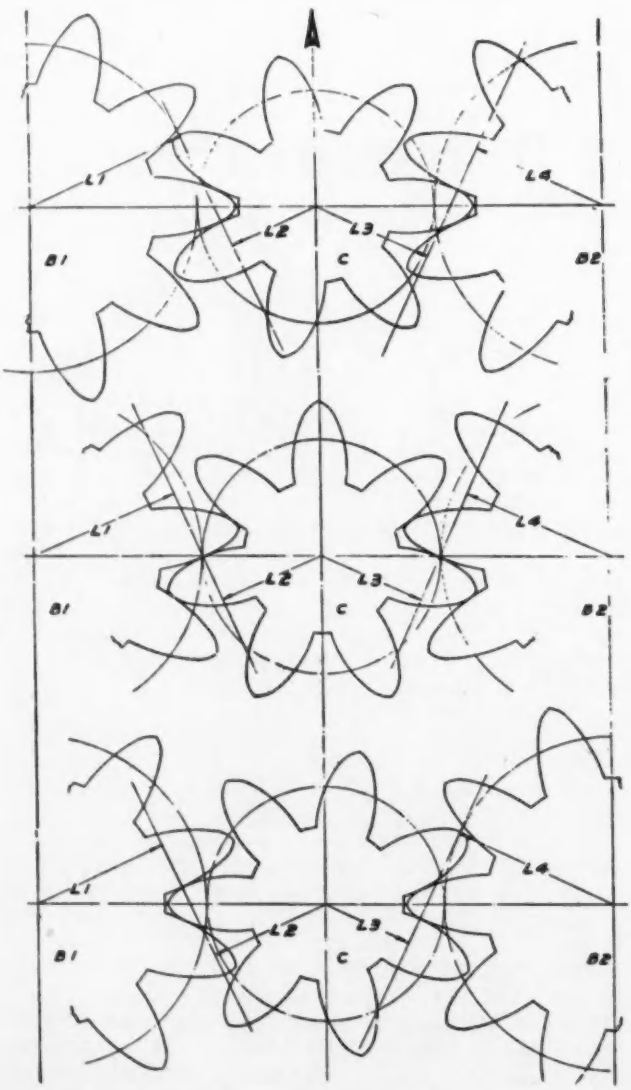




——Torque-Bias Type

Timken High-Traction Differential achieves unequal torque distribution by use of gearing having a special tooth form.

Gears for the Timken High-Traction Differential differ from gears for conventional bevel-gear differentials only in number and shape of teeth.

With conventional bevel gears, if one side gear is turned at constant angular speed, the other side gear will turn in the opposite direction at the same angular speed. This is because the differential pinions function as balance levers between the side gears, and the two arms of each lever always remain of equal and constant length. That is, the gearing is of the constant-velocity type.

With Timken High-Traction Differential gears, if one side is turned at constant angular speed, the other side gear will turn in the opposite direction at a continually varying angular speed. This is because the differential pinions function as balance levers with varying-length arms between the two side gears. The variation in length is determined by the relative angular position of the pinions on the axes. That is, the gearing is of the variable-velocity type.

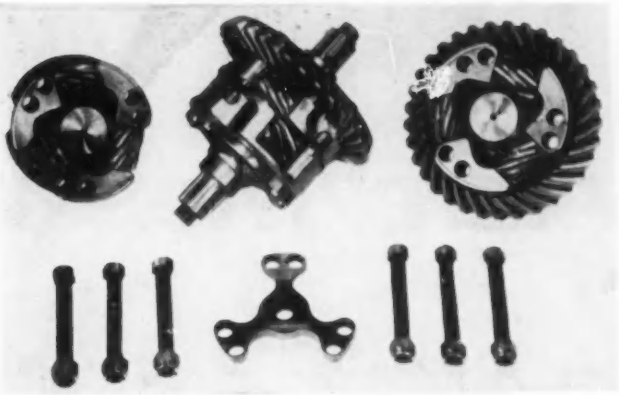
The diagrams show how leverage changes with pinion rotation. In the top diagram, lever L_3, which acts on the right-hand side gear, is of greater length than L_2 which acts on the left-hand side gear. For this position then, greater torque can be exerted on the left-hand side gear than on the right. In the center diagram, levers L_2 and L_3 are equal, giving equal torque on the two side gears. The bottom diagram is the reverse of the top diagram, and indicates greater torque on the right-hand side gear than on the left.

For straight-ahead travel with both driving wheels having equal traction, this differential will automatically move to the position shown in the middle diagram. Then it distributes torque equally to the two wheels. If one wheel has low traction, the differential pinions will automatically adjust themselves to distribute more torque to the other wheel as required by road conditions.

With a four-pinion High-Traction Differential of modern design, as much as 58% of the total torque can be distributed to the wheel having greater traction. This is 38% more torque than a conventional differential could deliver to this wheel under similar conditions.

It is evident that with the differential, if one wheel has no traction, it will spin. Too, as with any differential, if both wheels have no traction, both wheels will spin. However, there are many conditions of road surfaces varying between maximum and minimum traction of the driving wheels under which the High-Traction Differential will continue propulsion of the vehicle, where a conventional differential would allow one wheel to spin.

# of Differential——

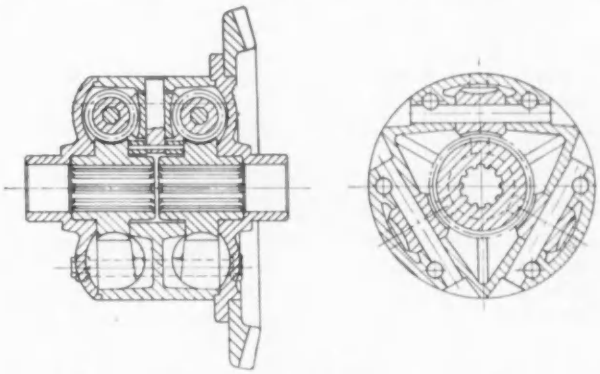


Walter Automatic-Lock Torque-Proportioning Unit is a differential used for several years by the Walter Motor Truck Co. in their heavy-duty four-wheel-drive trucks. The device proportions engine torque to the front and rear axles and serves also as a differential in these axles.

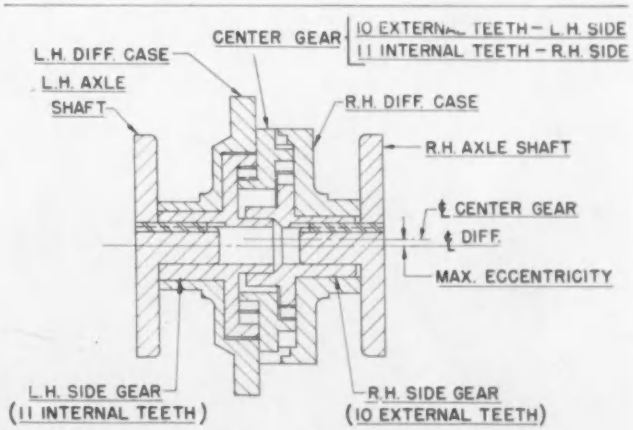
The assembly consists of two differential cases with a spacer between, two worm wheel-type side gears, and six worm pinions with axes circumferential. Three of the pinions are mounted on trunnions in each half of the differential case. Each pinion meshes with one side gear and with one other pinion in the opposite case half.

M & S Non-Slip Differential patented by Muhl and Scurlock, had three pinions with radial axes mounted on trunnions in the center member of a three-piece differential case. Three of the six other pinions were mounted on trunnions in the two end members of the case. Each meshed with one radial pinion and one side gear.

Lead angles were so selected that gearing was nonreversible. Differential action took place when one wheel was driven faster than the other by contact with the road. This is the condition in rounding a corner when both wheels have traction but not in straight motion when only one wheel has low traction. In rounding a corner, the outer wheel overran and the inner wheel did all the driving.



Sterling Super-Traction Differential has two cases with slots accommodating drive lugs, which are a part of the center gear. On one end of this center gear is an external gear. On the other, is an internal gear having one more tooth. All teeth are of cycloidal form. The two side gears have splined tubs to receive axle shafts. One side gear has one more internal tooth than the number of external teeth on the center gear. The other side has one less external tooth than the number of internal teeth on the center gear.



Power is transferred from the cases through the center gear teeth to the side gears. For straight-ahead drive with normal traction, the whole unit turns. Before one unit can turn faster than the other, frictional resistance within the gear train and between the lugs and case slots must be overcome. Then the inner side gear slows down and the outer speeds up. Because of the uneven number of teeth, the center gear changes position. This applies torque through one lug until resistance between it and the case is overcome. Then drive goes to the next lug, and so on until speed of the two driving wheels is equal.

While differential action is taking place, both wheels drive but torque is unequal because of the bias of the friction forces. This bias helps prevent spinning.

Aero Meeting Examines

AT the SAE National Aeronautic Meeting, held April 16-19 in New York, this pattern of future air transport took shape from operators' disclosures of their plans and needs:

- Helicopters to carry passengers, mail, and high-priority cargo on hops of 100 miles or less.
- A new 20–24 passenger, high-wing airplane to fly the feeder lines.
- Jet or turboprop transports for long hauls, which trunk-line operators hope, on the basis of military experience with turbines, will accomplish airport stops speedily.
- New flying boats more capable of open-sea operation for air-sea rescue work.

In the interim before these new aircraft become reality, U.S. operators will be getting more out of their current piston-engine fleets because of turbosuperchargers, improved engine lubrication, and—possibly—higher engine-oil temperatures.

Some of the ideas on jet transports advanced in the three days of technical sessions were reaffirmations of James C. Floyd's 1950 Annual Meeting paper on "The Avro C102 Jetliner," for which he received the Wright Brothers Award at the dinner Wednesday evening. Principal speaker at the dinner was H. Mansfield Horner, president, United Aircraft Corp. He assured his 400-odd listeners that helicopters the size of the DC-3 or even the DC-4 are almost certain to evolve in the next 10 years. Some jet-propelled commercial transports will be flying by 1955, but piston-engine craft will continue to predominate, he prophesied.

SAE President Dale Roeder welcomed the dinner guests and referred to the constant give and take of knowledge at SAE meetings as an important weapon in our arsenal. Casey Jones, president of the Academy of Aeronautics, presided.

Vice-Presidents and Chairmen

Left to right: M. G. Beard, general chairman of the meeting; R. J. Woods, SAE Vice-President representing Aircraft Activity; R. M. Hazen, SAE Vice-President representing Aircraft Powerplant Activity; R. D. Speas, chairman of the Air Show; and R. L. Anderson, SAE Vice-President representing Air Transport Activity

Future Transport Needs

Experts foresee new helicopters, feederliners, and flying boats sharing air with fast jet transports

On the last day of the meeting, Thursday, more than 500 SAE members and guests went out to New York International Airport at Idlewild to see for themselves today's antecedents of the helicopters and fixed-wing aircraft they had had prophesied for future use. After eating a box lunch served in the hangar with two of the U. S. Navy cosmic-research balloons said to be the basis of flying-saucer reports, the sightseers watched the flyaway of participating aircraft.

(Full coverage of this great Air Show, including special photographs, will appear in the June issue.)

At a technical session on helicopters, their proponents saw them as a stimulant to all forms of air traffic. Helicopters, one said, can close the gap between the airlines and the millions living within 100 miles of some airline-serviced airport. Plans were reported for Los Angeles Airways to branch out from mail carrying to transport of passengers from a heliport atop the Pacific Mutual Life Insurance Building to airports and to numerous outlying communities.

British European Airways has already experimented with passenger service over two routes, engineers learned, and has successfully flown mail schedules at night under instrument conditions. One of pilots' few complaints was that the reflection of operating lights and exhaust in surrounding clouds gave them the uneasy feeling of flying in a solid medium.

Both American and British operators estimated operating costs at $1.20 per mile.

They want their future helicopters to be multi-engined. BEA operates its present single-engine helicopters only when the ceiling is 500 ft or higher, to insure height for a safe let-down in case of engine failure. If this limitation could be removed by use of multi-engine helicopters, regularity would improve 10–20% on operations in the British Isles, bringing it up to 80 or 90%.

For Great Britain, the multi-engine helicopter was seen as the replacement for the aging DC-3.

American local service operators had another idea for covering 60–400 mile hauls. They asked

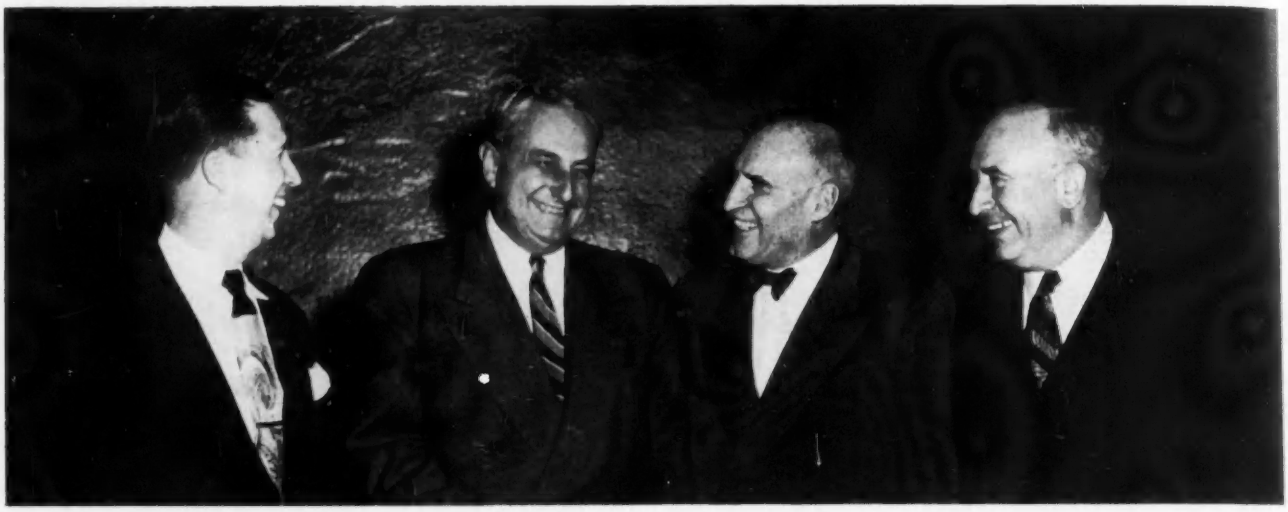
Under the general chairmanship of **M. G. Beard**, the following served as chairmen of the eight technical sessions of the 1951 SAE National Aeronautic Meeting: **C. E. Mines, Capt. C. H. Schildhauer, Charles Froesch, John R. Carver, Joseph Garside, F. S. Glass, R. D. Kelly**, and **R. L. Anderson.**

The all day panel on local Service Air Transportation was chairmanned by **R. D. Speas.**

This report is based on discussions and 18 papers . . . "First Use of Turbosuperchargers in Commercial Aviation" by **A. W. White, E. O. Hendrickson**, and **F. W. Fernald**, General Electric Co. . . . "Surging in Centrifugal and Axial Flow Compressors" by **R. O. Bullock** and **H. B. Finger**, National Advisory Committee for Aeronautics . . . "Influence of Turbine Engines on Transport Operating Costs" by **J. G. Borger** and **R. W. Blake**, Pan American World Airways . . . Symposium: Lastest Developments in Flying Boats—**J. D. Pierson**, Glenn L. Martin Co., **E. G. Stout**, Consolidated Vultee Aircraft Corp., and **Capt. D. B. MacDiarmid**, U. S. Coast Guard Air Station, San Diego . . . "Treatise on Experience—Review of Transport Aircraft Detail Design Difficulties and Their Remedies" by **W. W. Davies**, United Air Lines, Inc. . . . "Wanted—A New Airplane" by **T. H. Davis**, Piedmont Airlines . . . "Operating Cost Characteristics of Local Air Service Operations" by **C. W. Wendt**, All American Airways . . . "Passenger and Cargo Service Standards Required for Local Air Service" by **Mel Anderson**, Lake Central Airlines . . . "Aircraft Ground Handling Characteristics as Required for Maximum Efficiency" by **J. G. Ray**, Ray and Ray—Airline Consultants . . . "Local Service Aircraft and Engine Maintenance Requirements" by **Charles L. Baker**, Trans-Texas Airways . . . "Helicopters Applied to Local Air Service Operation—American Plan" by **C. M. Belinn**, Los Angeles Airways, Inc. . . . "Helicopters Applied to Local Air Service Operation—British Experience and Requirements" by **N. E. Rowe**, British European Airways . . . Symposium: Flight Experience with U. S. Turbine Powered Aircraft—"Flight Experience with Turbine Propeller Powered Aircraft" by **R. C. Loomis** and **E. D. Shannon**, Consolidated Vultee Aircraft Corp.; "Flight Characteristics of the B-47" by **R. M. Robbins** and **W. H. Cook**, Boeing Airplane Co.; "Operational Experiences with Multi-Engine Jet Aircraft" by **N. N. Davis** and **E. M. Beattie**, General Electric Co. . . . "Flight Research Experience with Higher Aircraft Engine Oil Temperature" by **D. N. Harris, F. R. Watson, T. Frame-Thomson**, and **D. C. McMacken**, Shell Oil Co. . . . "Airline Experience with Engine Lubricating Oils" by **H. N. Taylor**, United Air Lines, Inc.

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.

At the Dinner



Left to right: SAE Metropolitan Section Chairman E. N. Hatch, who opened the dinner proceedings; H. Mansfield Horner, president of United Aircraft Corp., chief speaker; Toastmaster Casey Jones, president of the Academy of Aeronautics; and SAE President Dale Roeder

for a new design capable of carrying 20–24 passengers and breaking even with a load of 10 or 12. Some want turboprops, but most will be content with piston engines. They say operation should require no more than three crew men: a pilot, a copilot who doubles as handler of passengers' baggage, and a male flight attendant who helps load and unload cargo at stops besides taking care of paper work and passengers' comfort during flight.

Operators backed up their requests for high wings and tricycle landing gear with three reasons. This arrangement gives:

1. Passengers a level floor while the airplane is on the ground and a good view when it is aloft.
2. Cargo handlers a conveniently low cargo door.
3. Mechanics easy access to servicing points.

Local service operators came prepared to argue that their new airplane should have reliable heating, cooling, and ventilating equipment but did not need pressurization. But a trunk-line operator's arguments that pressurization appeals strongly to passengers; allows much faster climb and descent; is readily obtainable from turbine engines; and brings with it ease of heating, cooling, and ventilating, won over the feeder-line men.

An analysis of local-service flying costs showed that speed and distance of hops are the basic factors. With this in mind, local-service operators specified a cruising speed of at least 200 mph at 4000 ft and a range of 350 miles in their dream airplane.

Discussion boiled down to the ideas that local-service lines certainly need an airplane whose operating costs are no more than 35¢ per mile, that development, prototype testing, and production of such an airplane would cost more than the small airlines can contract now to pay, and that practically the only hope for such a design is to have the U. S. government pay part of the cost. Operators reason that government money would be well spent on an economic new design that would enable them to operate with lower or no mail-pay subsidization.

Cost-conscious trunk-line operators debated maintenance economy of jets versus turboprops for their next fleets. Consensus was that either will be more expensive than piston engines during the debugging period. Turboprops applied to proved airframe designs would give airplanes cheaper to maintain than turbine engines in specially designed airframes. When both turbojets and turboprops are debugged and in common use, tuboprops are likely to have higher replacement costs because they have a greater number of delicate, expensive, hot-running parts.

But for a given payload and range, turboprops

Wright Brothers Award Presentation

J. C. Floyd, A. V. Roe Canada, Ltd., (left) receives the Wright Brothers Medal from H. D. Hoekstra, chief engineer, Aircraft Division, Civil Aeronautics Administration, who made the presentation for the Society. Floyd received the award in recognition of the technical excellence of his paper "The Avro C-102 'Jetliner' ", which he presented before SAE's 1950 Annual Meeting at Detroit

can accomplish the job in a smaller airframe than jets. And the smaller the airframe, the less the probable airframe maintenance.

Eager as operators were to find out about relative costs, they agreed that comparisons will be meaningless if jets attract all the business.

Whether the final choice is turbojets or turboprops or both, savings in maintenance of higher-pressure-ratio units should result from current NACA research reported on compressor surge—the flow pulsations that can severely damage an engine, as well as interfere drastically with performance.

Surge has been avoided in units where the pressure ratio is less than 7 or 8, it was explained, by matching turbine and compressor units so that the turbine flow demand line falls on the safe side of the surge area on the compressor's characteristic pressure-flow plot. But high-pressure-ratio units can't be so matched. As NACA researchers see it, either the compressor surge line must be shifted or the compressor's low-speed efficiency improved—or both. The solution may be to design individual stages for other-than-optimum conditions at the design point, staggering the conditions chosen for the various stages so that overall efficiency of the whole compressor is good at low-speed as well as design-point operation.

This, they hope, will improve fuel economy and performance of high-pressure-ratio turbojets and turboprops.

Trunk-line operators, taking it for granted that their next fleets will be very-high-speed jet or turboprop airplanes, were concerned with speed of let-down, ground handling, and take-off with these engines. The higher the flight speed, the more important they consider these maneuvers. They heard from pilots of several jet bombers—which are as close as anything the U. S. has to jet transports—that jets require more time for approach and landing. Dive breaks and some form of reverse jet thrust were recommended to save time in the transition from high-speed level flight to standstill at the terminal. Opinion was divided on advisability of drag parachutes for commercial operation, although all agreed that stopping a jet transport on a wet or icy runway is going to be a problem.

Cockpit checkout takes less time for jets than for piston-engine aircraft because of the simplicity of controls and inherent fire safety. Pilot and co-pilot of multi-engine jet transports will start engines simultaneously, it was foreseen, if the starting system can take the load.

A report on the experimentally turboprop-equipped Convairliner transport disclosed that engine check-out by ground crews before releasing the airplane for flight is much quicker than check-out of piston-engine craft. With the turboprop, check-out consists of a full-power check of fuel and speed schedules, an overspeed governor check with electronic governing inoperative, an operational idle check of fuel and speed schedules, and a full-reverse check. The whole procedure is accomplished in a matter of a few minutes after bringing the oil temperature up to minimum limits.

There is no engine run-up before take-off because there is nothing more to check. The flight engineer's major concern is to monitor indicators showing turbine inlet temperature, turbine speed, and fuel flow. He reports the indications to the pilot only if they are abnormal.

Average take-off of the B-45 jet bomber is accomplished in 27 sec with a ground roll of 2700 ft and a take-off speed of 130–135 mph. Jet planes characteristically have a very high optimum rate of climb in climb-out, it was reported.

Once aloft, future fast transports are expected to follow nearly transpolar routes to use or avoid the 100 mph and faster jet streams prevailing at high altitudes. As long as human error and gravity affect aircraft, there will be the chance that transports may be forced down on the sea, airmen conceded. Casualties will suffer greater shock and exposure.

For rescuing these people, we can't afford to be without a seaplane specially designed for air-sea search and rescue, one rescue expert insisted. Present seaplanes are doing good rescue work, but their open-sea operation is too limited, he continued. His solution to satisfactory open-sea operation involves:

1. Greater hull strength to take racking, pounding, and twisting from the sea.
2. Improved lateral stability, achieved possibly by use of inflatable boots about wing-tip floats.
3. Slow touch-down speed, made possible by slots, improved flaps, a droop snoot, and variable aspect ratio.
4. Quick deceleration, provided by spoilers, water

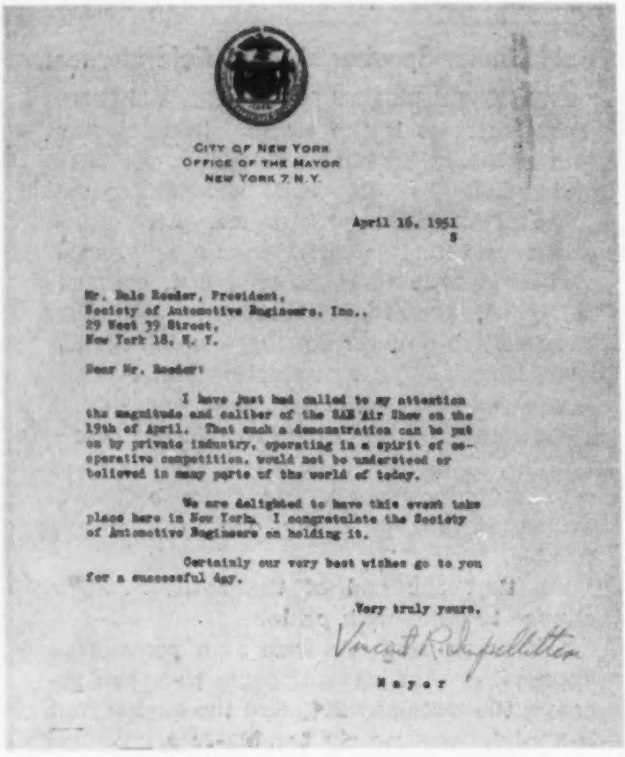
Said Dinner Speaker H. Mansfield Horner:

"ONE OF THE MOST INTRIGUING THINGS about aircraft is the eternal dissatisfaction which occurs in what would, in most other industries, be the end accomplishment. Take powerplants, for instance. After much sweat and tears a new engine is brought forth. It type tests, at long last, satisfactorily. It prototype flight tests with only the inevitable minor changes—which require scrapping half your production tools. Then it goes into service, and at once you're up to your neck in grief. Come the service fix redesigns, hours of bench testing, hours of service flight testing, and there begins to evolve an engine which doesn't give any trouble.

"Is that the end of the road? . . . The chance to point with pride?

"Of course not. As soon as a powerplant approaches *that* state of perfection, you increase the rating by 25% and the engine that last night was nearly trouble-free now has you right back in grief up to your neck again. But that, my friends, is progress!"

Horner is president of United Aircraft Corp.



CITY OF NEW YORK
OFFICE OF THE MAYOR
NEW YORK 7, N.Y.

April 16, 1951

Mr. Dale Roeder, President,
Society of Automotive Engineers, Inc.,
29 West 39 Street,
New York 18, N. Y.

Dear Mr. Roeder:

I have just had called to my attention the magnitude and caliber of the SAE Air Show on the 19th of April. That such a demonstration can be put on by private industry, operating in a spirit of co-operative competition, would not be understood or believed in many parts of the world of today.

We are delighted to have this event take place here in New York. I congratulate the Society of Automotive Engineers on holding it.

Certainly our very best wishes go to you for a successful day.

Very truly yours,

Vincent R. Impellitteri

Mayor

Tex and Jinx McCrary, well-known radio husband-and-wife team, delivered the above letter from Vincent R. Impellitteri, mayor of New York City, to SAE President Dale Roeder at the New York International (Idlewild) Airport. Starting from the new Heliport atop the New York Port of Authority Building in Manhattan, they flew to Idlewild by Sikorsky helicopter to deliver the letter to President Roeder as part of the SAE 1951 Air Show

brakes, reverse thrust, and a retractable step.

5. Very quick take-off, derived from JATO and flaps probably.

6. Very good aileron, rudder, and elevator control at slow speeds.

7. Comfort, convenience, and a good view of the sea ahead for the pilot.

8. High locations for all especially vulnerable parts such as propellers, flaps, and empennage.

9. Wing-tip floats to ride in half-down-but-braced position while the craft is running on the step.

Promise that we will be able to develop more seaworthy seaplanes came in reports on current basic hydrodynamic research applicable to seaplane design. Glenn L. Martin Co. is analyzing mathematically pressures, velocities, and dimensions in flow patterns around hulls. Martin engineers are also combining abovewater and underwater photographs of flow patterns around models in their studies to devise better forms.

One of their developments disclosed at the meeting is a special long-afterbody hull form. Greater safety and added comfort in high-speed travel through rough water were claimed for this design because of its control of pitching motion.

Using a revised concept of design and dynamically similar models, Consolidated Vultee is in a position today to take any requirements for water-based aircraft and guarantee to get the performance desired, it was reported. Work is done on the premise of building good airplanes first, then making hydrodynamics conform. Dynamically similar models used by Convair in development are radio-controlled from the ground by a pilot who sits in a cockpit, using full-size instruments. Often flight-test data are obtained on the small-scale model three years before the actual full-scale model is flown.

"Aviation in itself is not inherently dangerous, but to an even greater extent than the sea, it is terribly unforgiving of any carelessness, incapacity, or neglect," meeting participants were reminded. While designers go on with their brilliant complexities, they were warned not to overlook the simple fundamentals of design. One example cited was sharp notches that concentrate stresses, thereby shorting fatigue life. Evidence that this fact is sometimes overlooked came from a photograph—one among many of similar deficiences—of a rocker box cover with an unrelieved corner, formed by spot facing, so sharp that fatigue cracks resulted.

The way to avoid these "errors caused by knowing better but having forgotten," engineers agreed, is to alert practicing and student engineers to the importance of good detail design. Practicing engineers must get together to exchange knowledge between users, field service representatives, and designers on detail design flaws. (Greatest barrier to this communication was said to be the legal profession. Company lawyers, worried by recent subpoenaing of records of even informal post-accident conferences, tend to forbid any disclosures of faults.)

Student engineers must be imbued with the spirit of safety from the start of their technical education. The Flight Safety Foundation is attacking the problem by reviewing textbooks to see where safety-slanted examples can be interwoven, by urging introduction of assignments on safety topics into such courses as public speaking, and by sending speakers on safety subjects to address college groups, it was reported.

Let's have design taught by experienced designers, one chief engineer urged, noting that many professors have a string of degrees but lack practical experience. Schools must avoid giving the impression that board work is not engineering, he added.

Stratocruisers have accumulated over a million hours of operation on their General Electric BH4 turbosuper chargers charging Pratt & Whitney R4360 engines, it was disclosed. Average operating time to date is 2500 hr per turbo, or about 3½ months of continuous operation. Critical parts like the turbine wheel and nozzle box have been replaced from time to time. But most of the other original parts, including compressor parts, are still in service.

Stratocruisers are more severe on turbos than military planes, it was explained. Rotor speed is lower in the commercial application, but temperature of exhaust gas flow into the turbo is higher because airlines use leaner mixtures. Practically no fuel remains unburned to cool the mixture in the combustion chamber.

The more severe conditions have required numer-

Continued on Page 64

At the Aircraft Engineering Display

Capt. Madeline Barneycastle (left) Korean Air Lift veteran, and Capt. Barbara Beck, chief of nurses, Kelly Air Force Base, inspecting model of Boeing C-97 Stratofreighter converted to flying hospital. Planes are flown by Military Air Transport Service

Exhibitors:

Aeroquip Corp.
Anemostat Corp. of America
Barber-Colman Co.
Bendix Products Division, Bendix Aviation Corp.
Bendix Radio Division, Bendix Aviation Corp.
Boeing Airplane Co.
Chase Aircraft Co, Inc.
Cleveland Pneumatic Tool Co.
Curtiss-Wright Corp., Propeller Division
Elastic Stop Nut Corp.
Fafnir Bearing Co.
General Laboratory Associates, Inc.
Hydro-Aire, Inc.
Jack & Heintz Precision Industries, Inc.
Lear, Inc.
Micro Switch
Minneapolis-Honeywell Regulator Co.
Mitchell Mobilhangar Corp.
Monsanto Chemical Co.
New York Air Brake Co.
Purolator Products, Inc.
Resistoflex Corp.
Rohm & Haas Co.
Scintilla Magneto Division, Bendix Aviation Corp.
Solar Aircraft Co.
Stratos Division, Fairchild Engine & Airplane Corp.
Teleflex, Inc.
Thermix Corp.
Titeflex, Inc.
Trans World Airline, Inc.
Vickers, Inc.

Shown above are several photographs taken around the Aircraft Engineering Display held in connection with the meeting. Thirty-one companies had booths at the display—more than at any previous aeronautic meeting held in New York

Airlines Fly Flowers to Dinner Guests

Seven airlines, at the suggestion of General Chairman M. G. Beard, flew currently-blooming flowers for the dinner guests from faraway climes. The souvenirs were distributed by the hostesses, each from a different airline, who are shown here clustered around Chairman ("Lucky Dan") Beard.

Left to right the gals are: (front row) **Beth Eskew**, of United Air Lines, who distributed carnations from California; **Mickie Corbett**, of Northwest Airlines, whose gifts were orchids from Hawaii; **Elna Koval**, of Capital Airlines, who gave out carnations from New Orleans; **Florence Topoleski**, of Pan American, who attached heather from Scotland to the guests; (back row) **Paula Reid**, of Eastern Air Lines, who inserted tuberoses in the men's buttonholes; **Catherine Ritchie**, of American Airlines, who pinned orchids from Mexico on the ladies; and **Isabel Bart**, of Trans-Canada Air Lines, who brought roses from Canada.

ous design changes in the BH4. For example, turbine bucket shape has been tapered to reduce stresses in the blade. Other parts have been strengthened and made in more corrosion-resistant alloys.

Addition of the turbosuperchargers required revisions in the R4360 engine, also, for Stratocruiser use. Primarily, the trouble was excessive temperatures and pressures in the exhaust-port area. Valve stems ran so hot that lubricants tended to break down and to form deposits. The results were valve sticking and wear.

Two changes have greatly reduced the troubles: (1) Oil flow to rocker boxes has been increased so that they operate flooded; the oil pumps heat from the whole exhaust port area, improving valve operation and lessening rocker-box coking. (2) Spark has been advanced 5 to 8 deg over the former advance of around 20 deg; this dropped exhaust gas temperatures 30 to 50 F and markedly improved life of turbo parts.

Operators of older designs of piston engines are finding that they benefit from oil-in temperatures of 85-90 C instead of the usual 70 C or lower. Researchers who had tried higher temperatures listed these advantages:

1. Cleaner engines.
2. Reduced airplane drag (because oil-cooler air exit is closed during more of cruise operation).
3. Less engine friction.

If experience bears out these favorable effects of higher oil temperatures, considerably smaller oil coolers will suffice. Reason given is that with higher oil temperatures, the crankcase will dissipate a larger proportion of the waste heat, so the oil cooler will have a lesser load. Besides, it will be more efficient because the oil-air temperature gradient will be greater.

One of the highlights of the SAE 1951 Air Show at the New York International (Idlewild) Airport—which took place on the final day of the meeting—was the demonstration put on by Air Force jet planes, such as the North American F-86 shown above making a pass over the assembled group of SAE'ers. Full story of this remarkable show, complete with pictures, will be included in the June issue

CALENDAR

Atlanta Group—May 18

110 Forsythe Street; dinner 7:00 p.m. Meeting 8:00 p.m. Automotive Body Construction—Harry E. Chesebrough, assistant chief body engineer, Chrysler Corp.

Canadian—May 18

Hotel Oshawa; dinner 7:00 p.m. Meeting 8:00 p.m. Higher Octane Fuels and Higher Compression Engines—C. L. McCuen, vice-president and general manager, Research Laboratories Division, GMC. Golf in afternoon, reception at 6:00 p.m.

Central Illinois—May 28

Hotel Jefferson; dinner 6:30 p.m. Meeting 7:45 p.m. How to Hunt Ideas—Henry Haupt, vice-president in charge of Chicago Office, Baton, Barton, Durstine, & Osborn.

Chicago—May 8

Hotel Knickerbocker, Chicago; dinner 6:45 p.m. Meeting 8:00 p.m. Mechanical Octanes—Alex Taub, consulting automotive engineer, Alex Taub Associates. Social Half-Hour 6:15 p.m. to 6:45 p.m., sponsored by Sinclair Refining Co.

Cincinnati—May 28

Engineering Society Headquarters; dinner 6:30 p.m. Meeting 8:00 p.m. Speaker to be announced.

Cleveland—May 14

Rockside Club, Cleveland; dinner 6:30 p.m. Meeting 7:30 p.m. A Comparison of Hydraulic Transmissions—Harold O. Flynn, resident engineer, Chevrolet Plant, GMC. Plant tour through Chevrolet Plant preceding dinner.

Detroit—May 7

Rackham Educational Memorial Building, large auditorium, dinner 6:30 p.m. Meeting 8:00 p.m. The Patton Tank in Korea—W. O. Miller, Army Ordnance Corps. SAE President Dale Roeder will also be on program. Dinner entertainment by Bob Hall.

Mid-Michigan—May 15

Owosso Country Club; dinner 6:30 p.m. Meeting 8:00 p.m. Instrumentation—Prof. W. E. Lay, University of Michigan. Demonstration on combustion analysis. Film "Hidden World."

Milwaukee—May 4

Wagon Wheel Lodge, Rockton, Ill.; dinner 6:45 p.m. Meeting 8:00 p.m. The Manufacture and Metallurgy of Cast Alloy Crankshafts—R. O. Johnson, assistant chief metallurgist, Fairbanks, Morse & Co. Shear Modulus of Cast Crankshaft Alloys—Part I: J. D. Swannack, chief analyst, design calculations; Part II: R. J. Maddock, design analyst, design calculations. Both authors are with Fairbanks, Morse. Papers are to be presented after a plant trip to the company's Beloit Works.

Mohawk-Hudson Group—May 9

Hotel Wellington, Green Room, Albany; dinner 6:30 p.m. Meeting 8:00 p.m. Valve Rotation — Herbert C. Sumner, Ethyl Corp.

Northern California—May 23

Engineers Club; dinner 6:30 p.m. Diesel meeting, topic to be announced. Herbert B. Ford, sales training program development, GMC Truck and Coach Division. Discussion by Darryl F. Lemaux, assistant experimental engineer, GMC Truck and Coach Division.

Philadelphia—May 11

Bala Golf Club, dinner 6:30 p.m. Ladies Night. SAE President Dale Roeder will visit Section.

Pittsburgh—May 16

Wenango Country Club, Oil City; dinner 6:30 p.m. Meeting 8:00 p.m. Engineering Aspects of Road Racing—W. F. Milliken, Jr., manager of flight research, Cornell Aeronautical Laboratory, Inc. This is the annual spring outing meeting of the Pittsburgh Oil City Section. Round Table discussions follow luncheon. Golf and other activities complete the afternoon schedule.

St. Louis—May 8

Hotel Congress; dinner 6:30 p.m. Meeting 8:00 p.m. Helicopters Applied to Local Air Service Operation—American Plan—F. W. Milam, operations manager, Los Angeles Airways, Inc. Discussions by Brig.-Gen. William Fox. Film on Helicopter Operations in Korean War Zone.

Twin City—May 9

Hotel Curtis, Solarium; dinner 6:30 p.m. Meeting 8:00 p.m. Manufacturer's Research Genesis Evaluation—J. W. Armour, manager of manufacturer's research, International Harvester Co.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
	1951	
SUMMER	June 3-8	French Lick Springs Hotel, French Lick, Ind.
WEST COAST	Aug. 13-15	Olympic, Seattle, Wash.
TRACTOR and PRODUCTION FORUM	Sept. 10-13	Schroeder, Milwaukee
AERONAUTIC, PRODUCTION FORUM, and Display	Oct. 3-6	Biltmore, Los Angeles
TRANSPORTATION	Oct. 29-31	Knickerbocker, Chicago
DIESEL ENGINE	Oct. 29-30	Drake, Chicago
FUELS and LUBRICANTS	Oct. 31-Nov. 1	Drake, Chicago
	1952	
ANNUAL	Jan. 14-18	Book-Cadillac, Detroit

SAE 1951 Summer

ROOM RESERVATIONS

Please apply directly to the hotel for rooms.
To provide better accommodations for SAE members, and their immediate families, reservations this year will be restricted.

SUNDAY, June 3

8:30 p.m. — Convention Hall

FEATURE MOTION PICTURE

(To be announced)

MONDAY, June 4

9:30 a.m. — Convention Hall

M. C. HORINE, Chairman

Military Wheeled Transport Vehicle Requirements—Types of Trucks and Components Required
—COL. W. A. CALL, Ordnance Corps, Detroit Arsenal
(Sponsored by Truck and Bus Activity)

ROUND TABLES

2:00 p.m. to 4:00 p.m.

Subject and Sponsoring Activity	Leader and Secretary if to be reported	Location
Plastic Model Techniques (Body)	Leader—R. L. LOGUE, Kaiser-Frazer Corp. Secretary—JESSE RICHARDS, Kaiser-Frazer Corp.	Japanese Gardens
Automotive Seating (Body)	Leader—E. C. PICKARD, Ford Motor Co. Secretary—E. R. LANGTRY, Ford Motor Co.	South Front Porch
Polishing the Paint (Transportation and Maintenance)	Leader—G. W. JOHNSON, Bowman Dairy Co. Secretary—HENRY JENNINGS, Fleet Owner	South Foyer
Synchronizers for Truck Transmissions (Truck and Bus)	Leader—W. P. MICHELL, Spicer Mfg. Division, Dana Corp. No reporting	Front Lawn

8:30 p.m. — Convention Hall

F. K. GLYNN, Chairman

Talented Transmissions
—J. T. BUGBEE, The Texas Co.

Symposium—Automatic Transmissions and Torque Converters

W. B. HERNDON, Detroit Transmission Division, GMC
A. H. DEIMEL, Spicer Mfg. Division, Dana Corp.
P. R. YOUNGS, Schneider Mfg. Corp.
R. M. SCHAEFER, Allison Division, GMC
O. K. KELLEY, Engineering Staff, GMC
F. R. McFARLAND, Packard Motor Car Co.
D. T. SICKLESTEEL, Detroit Gear Division, Borg-Warner Corp.
(Sponsored by Transportation and Maintenance Activity)

TUESDAY, June 5

9:30 a.m. — Convention Hall

C. J. LIVINGSTONE, Chairman

Possible Mechanisms by Which Combustion Chamber Deposits Accumulate and Influence Knock
—L. F. DUMONT, E. I. duPont de Nemours and Co., Inc.
Effects of Combusion Chamber Deposits on Octane Requirement and Engine Power Output
—J. B. DUCKWORTH, Standard Oil Co. (Indiana)
Prepared Discussion by:
—C. A. HALL, Ethyl Corp.
(Sponsored by Fuels and Lubricants Activity)

ROUND TABLE

2:00 p.m. to 4:00 p.m.

Subject and Sponsoring Activity	Leader	Location
Diesel Engine Combustion Systems (Diesel Engine)	Leader—E. T. VINCENT, University of Michigan No reporting	North Foyer

Meeting

June 3-8, French Lick, Ind.

2:00 p.m. Convention Hall

PANEL

Question and Answer Forum on Combustion Chamber Deposits

Moderator—A. T. COLWELL, Thompson Products, Inc.
Secretary—A. L. POMEROY, Thompson Products, Inc.
Panel of Experts:
J. M. CAMPBELL, General Motors Corp.
V. G. RAVIOLO, Ford Motor Co.
W. E. DRINKARD, Chrysler Corp.
H. J. GIBSON, Ethyl Corp.
J. R. SABINA, E. I. duPont de Nemours and Co., Inc.
D. P. BARNARD, Standard Oil Co. (Indiana)
W. M. HOLADAY, Socony-Vacuum Oil Co., Inc.
(Sponsored by Fuels and Lubricants Activity)

8:30 p.m. Convention Hall

P. C. ACKERMAN, Chairman

Calthrop's Streamlined Train—1865
—HAROLD VAN DOREN, Industrial Designer
(Sponsored by Body Activity)

WEDNESDAY, June 6

9:30 a.m. Convention Hall

W. J. PELIZZONI, Chairman

The Experimental High Speed Cummins Diesel Engine 4000 rpm—345 hp—401 cu in.
—N. M. REINERS and R. C. SCHMIDT, Cummins Engine Co., Inc.
Prepared Discussion
(Sponsored by Diesel Engine Activity)

ROUND TABLES

2:00 p.m. to 4:00 p.m.

Subject and Sponsoring Activity	Leader and Secretary if to be reported	Location
Lubrication Problems of Aircraft Powerplants (Aircraft Powerplant)	Leader—D. N. HARRIS, Shell Oil Co. Secretary—to be named	South Front Porch
Frame versus Frameless Bodies (Passenger Car)	Leader—F. F. KISHLINE, Nash Motors Division, Nash-Kelvinator Corp. Secretary—L. H. NAGLER, Nash Motors Division, Nash-Kelvinator Corp.	Front Lawn

WEDNESDAY, June 6

COUNTRY CARNIVAL

7:30 p.m. Convention Hall

The Entertainment Committee offers an evening packed with diversified entertainment.

Beginning promptly at 7:30, the Convention Hall will be the scene of spirited, nonsensical fun. Everybody will be there.

The nose-tickling odor of popcorn, blended with musical strains of a calliope, will introduce the pitch games, fortune teller, caricature artist, photographer, and the evening's hilarity-packed entertainment. Round and Square Dancing plus a scintillating floor show will leave you gasping, laughing, and applauding.

So, bring your plaid shirts, blue jeans, and straw hat (they may be worn to dinner). Come prepared for an evening of relaxation and SOMETHING DIFFERENT!

THURSDAY, June 7

9:30 a.m. Convention Hall

R. P. ATKINSON, Chairman

*Current Foreign Aircraft Engines
—Lt. COL. KENT PARROT, USAF,
Intelligence Department, Air Materiel Command

An Improved Method for Estimating the Fatigue Life of Bevel Gears and Hypoid Gears
—WELLS COLEMAN, Gleason Works

Continued on next page ——▶

SAE Summer Meeting Program

Continued

Compressor Inlet Design and Experimental Development
—J. A. KING, Fairchild Engine Division,
Fairchild Engine and Airplane Corp.
(Sponsored by Aircraft Powerplant Activity)

* This session will begin as a restricted meeting. For the presentation of the first paper, attendance will be strictly limited to citizens of the United States who possess evidence of current clearance through CONFIDENTIAL, by the Air Force, Navy, or other accredited U. S. Government agency. Before entering the meeting room each person will be required to execute a certificate showing that he is a U. S. citizen currently cleared through CONFIDENTIAL, and giving the date of such clearance and the name of the authorizing Government agency. Persons intending to attend this restricted meeting should come prepared to execute such certificate.

At 10:30 a.m. the meeting will be opened for general attendance during the presentation of the second and third papers.

ROUND TABLES

2:00 p.m. to 4:00 p.m.

Subject and Sponsoring Activity	Leader and Secretary if to be reported	Location
Production of Aircraft Engines and Accessories by the Automobile Industry (Aircraft Powerplant)	Leader—E. H. KELLEY, Chevrolet Motor Division, GMC No reporting	Front Lawn
Compressor Surge (Aircraft Powerplant)	Leader—WALTER DOLL, Pratt and Whitney Aircraft, Division of United Aircraft Corp. Secretary—J. R. FOLEY, Pratt and Whitney Aircraft, Division of United Aircraft Corp.	Japanese Gardens
New Aspects of Wear (Engineering Materials)	Leader—P. S. LANE, Muskegon Piston Ring Co. Secretary—V. A. CROSBY, Climax Molybdenum Co.	South Front Porch
Problems of Automatic Transmissions (Passenger Car)	Leader—O. K. KELLEY, Engineering Staff, GMC Secretary—R. L. McWILLIAMS, Technical Data Section, GMC	Convention Hall
Automobile Noise and Vibration (Passenger Car)	Leader—A. C. BODEAU, Ford Motor Co. Secretary—R. H. FASHBAUGH, Ford Motor Co.	North Foyer

8:30 p.m. — Convention Hall

HAROLD NUTT, Chairman

Studebaker V-8 Engine
—E. J. HARDIG, T. A. SCHERGER, and S. W. SPARROW, The Studebaker Corp.
Prepared Discussion
(Sponsored by Passenger Car Activity)

FRIDAY, June 8

9:30 a.m. — Convention Hall

L. RAY BUCKENDALE, Chairman

Methods for the Evaluation of Loads and Stresses in Machine Design
—F. G. TATNALL, Baldwin-Lima-Hamilton Corp.

Recent Developments in the Extrusion of Metals
—R. T. HURLEY and V. T. GORGUZE, Curtiss-Wright Corp.
(Sponsored by Engineering Materials Activity)

SPORTS AND SOCIAL

GOLF

Again a six-day program of men's and ladies' tournaments is being planned by your Golf Committee. Anyone—from a duffer to a champ—can win a prize. Two championship 18-hole courses. Bring your clubs.

SKEET AND TRAP SHOOTING

Returning to the Summer Meeting this year by popular demand . . . skeet and trap shooting tournaments with prizes for the winners! Bring your gun. Or, guns will be available at French Lick. Shells will also be provided.

OTHER SPORTS

Facilities are available for tennis, swimming, horseback riding, bowling, pool, billiards, and table tennis.

SOCIAL

Dancing every weekday evening; bridge and keno for the ladies. Details on all events will be available at the meeting.

News of the Society

New Committee Chairman

B. N. Ashton, President of Electrol, Inc., recently appointed Chairman of SAE Committee A-12, Aircraft Shock Struts. This committee reviews and makes comments on military specifications related to shock struts and associated equipment. It also works on industry problems arising from new developments

SAE Cold Test Observers Meet

FIFTEEN of the 28 SAE observers of part of this year's Ordnance cold weather tests at Devil's Lake, N. D., met to exchange views and information in Detroit on March 22. Results of the session were summarization of SAE observers' ideas.

Observers present at the Detroit meeting were Chairman H. Collins of GM Research; D. L. Davis, Studebaker; W. C. Edwards, Delco Remy; L. D. Gilmore, Heil Co.; J. Kinnucan, Continental Motors; M. J. Kittler, Holley Carburetor; H. W. Klas, Willys-Overland; E. B. Lanman, Bucyrus-Erie; G. W. Lewis, Electric Auto-Lite; J. G. Lewis, GM Truck & Coach; K. F. Maier, Reo; D. L. Raymond, Perfection Stove; W. E. Rheault, Young Radiator; E. C. Sintz, Cadillac; and J. Thomas, Mack.

Screw Thread Committee Chairman Robert Cummings stopped at SAE headquarters on his way to London

Nut-Bolt Standards Unification Sought

ROBERT CUMMINGS, Ford Motor Co., who is chairman of SAE's Screw Threads Technical Committee, is in London as a member of an American Standards Association group aiming at unification with the British and Canadians on a standard for hexagon bolts and nuts. SAE and the American Society of Mechanical Engineers are co-sponsors of the ASA Sectional Committee (B-18) which the ASA group represents.

Any agreements reached by the London conference will be tentative and will be referred back to the ASA B-18 Sectional Committee for final approval. Problems involved in working out details of the proposed American standard also will be referred back to B-18.

The work of this standardization group takes on special importance at this time because of the urgent need for unification of American standards with the Canadian and British military services.

Closing Date for Voting Made Earlier

Beginning next fall with the election of 1952 SAE officers, voting will be closed Nov. 30, instead of Dec. 15, as in the past. Tellers of election will count the ballots, as heretofore, within seven days after voting closes.

Revisions in by-law 16 and by-law 17 which bring about these procedural changes, include also a provision that ballots shall go out not later than Oct. 20, instead of not later than Nov. 1 as previously. The revisions were approved by the SAE Council at its April 18 meeting in New York.

The earlier voting closure date will permit notices for many Annual Meeting committee meetings to be sent two weeks earlier. Thus, members will have more time to make arrangements to attend. With committee meeting notices held until after the old Dec. 15 closing date, many members learned of the meetings too late to plan attendance readily.

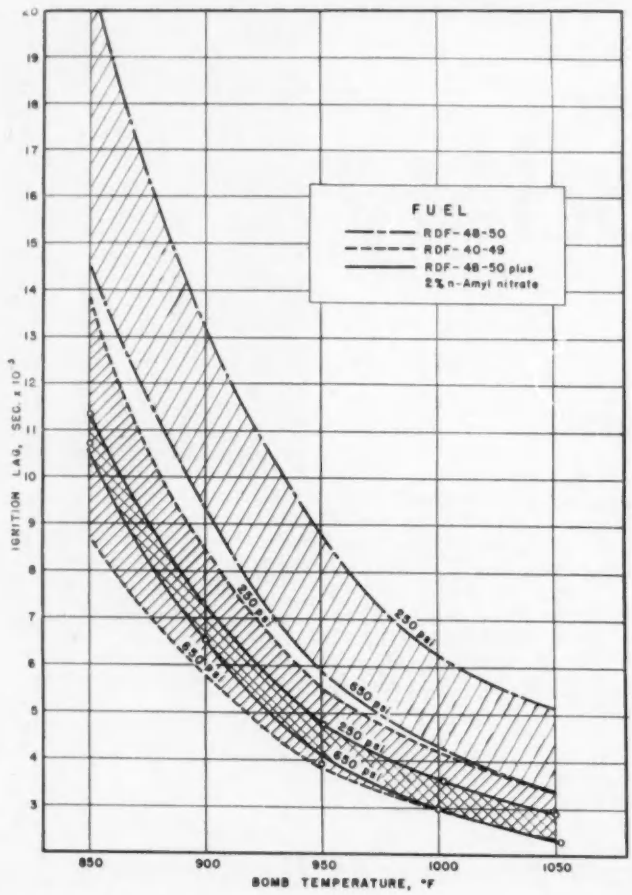


Fig. 1—Effect of normal amyl nitrate additive in lowering ignition delay. Note the relative insensitivity of the doped fuel to pressure changes

Constant-Volume Bomb Proves Worth

Based on paper by

R. W. HURN
and
K. J. HUGHES
Bureau of Mines

A series of tests was initiated to determine the effect of one particular additive on the shape of the combustion curves of a relatively low grade of diesel fuel. The constant-volume combustion-bomb technique was used because it promised to be satisfactory with small samples and to permit comprehensive investigation of the fuel's characteristics over a wide range of operating conditions.

The fuels used were RDF 48-50, both clear and treated with normal amyl nitrate, and RDF 40-49. The cetane number of the undoped 48-50 fuel was 36.6, and the doped fuel 56.2.

The lowering of ignition delays for the doped fuel is shown in Fig. 1. Furthermore, it is apparent that the spread in ignition delays between the two pressures, 250 and 650 psi, was quite small for the doped fuel as compared to other fuels that have comparable ignition delays. This is shown by the cross-hatched and double hatched areas of the chart. Here the relative insensibility of the doped fuel to pressure change is readily apparent.

Definite conclusions regarding this phenomenon must await further researches. But in view of the fact that previous work has indicated the influence of pressure changes to be largely an effect of increasing availability of oxygen, it would follow that doped fuel is less sensitive to change of oxygen availability. Two possible mechanisms resulting in this insensitivity are suggested:

First, the function of the additive may be to supply oxygen for initiation of combustion in the bomb. Second, the additive itself may be oxidized more readily to release heat and this local temperature may decrease the pressure sensitivity for the remaining fuels. Either or both of these explanations would be consistent with observed combustion behavior.

This paper also presents the results of other constant-volume combustion-bomb tests. (Paper "Combustion Characteristics of Diesel Fuels as Measured in a Constant Volume Bomb," was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers).

Ways to Measure Defects In Production Lapping

Based on paper by

CHARLES R. MOORE
General Motors Corp.

SURFACES finished by conventional mass production techniques such as milling, precision turning or facing, and grinding, have defects which sometimes seriously influence the final operation of the mechanism. These defects can be classified into two types, both of which can be corrected by some variation in the lapping process.

The first type, surface roughness, is produced by the cutting tool used. Grinding makes a scratch pattern nearly always in one direction, the magnitude of which is a function of abrasive grain size in the wheel, bonding of the abrasive, and method of truing.

Milling and precision turning leave a tool mark the nature of which is determined by the rate of feed across the part and the shape of the cutting edge. This type of defect usually can be measured with conventional surface roughness indicators such as the "Profilometer," "Brush Analyzer," and "Fax-Film," usually in terms of microinches.

The second type is the broad deviation from the basic surface sought. If a flat surface is desired the error would be the deviation of any part of the area from a theoretically perfect plane touching the part. This can be checked by such elementary methods as placing the part on an accurate surface plate, then checking for open spaces with a feeler gage. A better way is to set up the part on a surface plate with toolmaker's jacks with the surface exposed upward in such a manner that some three points indicate zero with a height gage when indicated from surface plate, then explore all other points on the surface

for deviation from the plane so established.

Still another way would be to coat the surface plate with toolmaker blue, pass the part over the plate, then examine the pattern of blue on the part. The most accurate method, however, is by the use of an optical flat and monochromatic light which, when placed upon the surface, will indicate by interference bands of light, the degree of flatness of the surface. This method is practical only for surfaces that are relatively accurate and will reflect light.

Deviations from a true cylinder or other geometric form would also be included here and are generally checked by the use of an accurately ground master and toolmaker's blue.

Generally, this second class of defect is caused by difficulties in the machine itself, or the fixture holding the part, such as spindle bearings, inaccurately machined or worn ways, lack of rigidity of machine frame and last, but probably, and most difficult to eliminate in mass production, by distortion of the part during the finishing operation caused by fixture clamping pressure.

(Paper "Mass Production Lapping Techniques" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Airline Growth Hinges On Greater Safety

Based on paper by

JEROME LEDERER

Flight Safety Foundation, Inc.

TO conclude that an important item may be needed so seldom that it should not be adopted is a fundamental error in safety thinking in aviation. It is true that Item A may fail only once in 50,000 hr, Item B once in 100,000 hr, Item C once in 20,000 hr. But the cumulative total of all the things that go wrong averaged up in 1950 in scheduled operations to one accident in every 14,000,000 miles of flying. Fatalities occurred in seven of these accidents and 145 passengers were killed.

This is a very good record, but not good enough. It does not include near accidents. Management should at all times recognize that safety in aviation is dependent on attention to all the things that may go wrong. If each safety measure is considered independently of the whole, judgment becomes distorted and may lead to dangerous decisions on the economics of safety expenditure.

Statistics have a very important place in rationalizing the solution to safety problems, but there exists a tendency to resist a design change, requiring the adoption of a safety measure, until sufficient statistics are gathered to prove that the corrective step is necessary. This line of reasoning can be carried to illogical extremes in both directions, one of requiring too many statistics, or the other of acting before enough are secured.

There are fortunately not enough accidents in aviation to furnish the mass data needed for statistical analysis. The problem is to secure information on the near misses, and one solution is to have a place where personnel can confess without being ridiculed or punished or publicly casting reflection on fellow workers.

In the absence of statistics, the designer, operator, or executive is often forced to rely on professional judgment when deciding a course of action. This should continue to some extent because statistics alone may at times give the wrong answer if all the variables are not included, or if they are incorrectly weighed. But the laws of statistical probability have a great future in aviation when applied to fundamental problems of design and operation.

Aggressive seeking of accident prevention data should be the responsibility of government and industry alike. Industry should not wait for the government to dictate measures

Continued on Page 100

Coordinating Research Council Balance Sheet

Below are given condensations of the audited balance sheet and operating statement of the Coordinating Research Council, Inc. of which the American Petroleum Institute and the Society of Automotive Engineers are the sustaining members:

Condensed Balance Sheet as of Dec. 31, 1950

Assets

Cash	$ 35,969
Accounts Receivable	40,746
U. S. Savings Bonds	59,920
Miscellaneous	1,971
Total	$137,606

Liabilities and Reserves

Accounts Payable	$ 23,519
Contributions Applicable to 1951	10,702
General Reserve	104,385
Total	$138,606

Operating Statement for the Year Ended Dec. 31, 1950

Income

Contributions—	
American Petroleum Institute	$ 25,000
Society of Automotive Engineers	25,000
Other	24,351
Military Contracts	84,254
Miscellaneous	1,697
Total	$160,302

Expenses

Motor Fuel Division	$ 27,363
Aviation Fuel Division	11,960
Diesel Fuels, Fuel Division	28,119
Coordinating Lubricants Research	10,281
Military Projects	84,448
Total	$162,171
Excess of Expense over Income	$ 1,869
General Reserve, Jan. 1, 1950	106,254
General Reserve, Dec. 31, 1950	$104,385

About

C. I. OCHS has been elected chairman of the board of directors of the Eaton Mfg. Co., Cleveland. Ochs joined Eaton in 1916, and held various positions with the company until 1925 when he was made president.

JAMES C. ZEDER, vice-president and director of engineering and research for Chrysler Corp., has been appointed a director of the corporation. He has been with Chrysler since its organization in 1925, and was the first chairman of its Engineering Board, in 1946. A past-president of SAE, Zeder also was chairman of the SAE War Engineering Board during World War II, and founder and 1948 chairman of the SAE Technical Board.

LEE DOUGLAS, chief engineer of the Piasecki Helicopter Corp., Morton, Pa., has been elected to the newly created position of vice-president in charge of engineering. Douglas came to Piasecki as chief engineer in 1949.

E. C. SULZMAN has been elected vice-president and appointed general sales manager of Jack & Heintz Precision Industries, Inc., Cleveland. Sulzman was associated for many years with Wright Aeronautical Corp., Wood-Ridge, N. J., as chief field engineer and, for the past six years, as sales engineer.

ROBERT L. ADAMS, previously an administrative engineer with the ECE Division of Philips Laboratories, Inc., Irvington, N. Y., is presently a research engineer in the Department of Mechanical Engineering, Harvard University, Cambridge, Mass. He is engaged in research engineering on ship propulsion powerplant development for the Office of Naval Research.

F. J. BREITSAMETER, who prior to this, was employed by the Hyatt Bearings Division, GMC, as an engineer, is now Chicago manager of the Timesaver Products Co.

WARREN L. GILMORE is now a senior propulsion engineer with the Glenn L. Martin Co., Baltimore, Md. He was previously a mechanical engineer with the National Advisory Committee for Aeronautics, Cleveland Airport, Ohio.

GEORGE H. GILL is now chief engineer with Electro-Aire, Inc., North Hollywood, Calif. Prior to this, he held a similar position with the Spangler Valve Co., Los Angeles. He is in charge of design and production engineering, and small aircraft motors and solenoids.

STUART H. SMITH, previously a district manager with SKF Industries, Inc,. in Cincinnati, Ohio, is now an assistant sales manager with that same company in Philadelphia.

B. V. RONCO has assumed the position and duties of chief engineer at Morrison Steel Products, Inc., Buffalo, N. Y. He had been chief inspector at Mack Mfg. Corp., Allentown, Pa., for the past 14 years, and for 10 years previous to that, he worked in various capacities in the engineering department of that same company.

Members

JAMES M. REYNOLDS, formerly motor equipment engineer for the Michigan Bell Telephone Co., Detroit, is presently a member of the technical staff with Bell Telephone Laboratories, Whippany, N. J. He is an engineer in the military electronics department.

LT.-COM. LAURIE C. SMITH, USNR, has been recalled to active duty. He is assistant inspector of Navy material, U. S. Navy, Fairbanks, Morse & Co., Beloit, Wis. He was previously an engineering designer with Hughes Aircraft Co., Culver City, Calif. His new assignment entails the inspection of navy material and development contact administration.

ADOLPH I. LOSICK, who, prior to this was technical sales representative with Alox Corp., New York City, is now employed by the Barrett Division of Allied Chemical & Dye Corp. in that same city, as market research assistant. He analyzes market trends and the projecting demand for coal for chemicals, and appraises markets for new products.

DANIEL H. SHAPIRO has joined North American Aviation, Inc., Los Angeles, Calif. He was formerly a project engineer with B. G. Corp., New York City.

LOUIS M. FITENY is now a development engineer with the Detroit Transmission Division, GMC. Prior to this, he was a test engineer with the Hamilton Standard Propellers Division of United Aircraft Corp., East Hartford, Conn.

ROBERT BEST, previously a test engineer with Fredric Flader, Inc., North Tonawanda, N. Y., is presently employed by Southwest Research, Inc., San Antonio, Texas.

BART COTTER has been appointed director of engineering of the Fisher Body Division, GMC, Grand Blanc, Mich., tank plant. Cotter formerly held the position of assistant chief engineer of the central engineering division in Detroit.

GENE T. NEUDECK has been appointed general sales manager of the V. L. Graf Co., Romeo, Mich. Prior to this, he was sales engineer with Aeroproducts Division, GMC, Dayton, Ohio, with whom he had been associated for 10 years.

JAMES B. CARTER of James B. Carter, Ltd., Winnipeg, Canada, has announced the appointment of **L. E. WINDSOR** as their new production engineer and works manager. Windsor was formerly the head of the engineering department of the Automotive Division of Canadian Car & Foundry Co., Ltd., Fort William Plant.

LEO L. HUNTER has been appointed to represent for the Perfect Circle Corp., Hagerstown, Ind., as sales engineer in the Chicago area. Hunter joined Perfect Circle in June, 1940 after receiving his mechanical engineering degree from Purdue University.

Autobiographer W. B. Stout

"SO AWAY I WENT" is the appropriate title of Past President **W. B. Stout's** latest book which Bobbs-Merrill, Inc., Indianapolis publishers have recently released.

Dedicated to Mrs. Stout, "the continued inspiration for everything," the 319 pages of engineering adventure carry the reader delightfully into the warm detail of inventive and engineering accomplishment — from whittling and kite-flying on through the Stout Bicar, the Cyclecar, various original airplanes, the Stout Airlines, a railcar, a rear-engined bus, the Scarab and Stout portable housing. It's all there, with incidents, names, places, and people.

In fact, Mr. Stout's chapters are well peopled with interesting men and women who have helped to make life obviously interesting, productive, and "a lot of fun" for the widely appreciated inventor, engineer, philosopher, and author.

E. M. ESTES, formerly assistant motor engineer, Oldsmobile Division, GMC, has been promoted to chassis engineer with the same company.

JAMES E. VINCENTY is now project engineer, axles and drive shafts, with the Lincoln-Mercury Division of Ford Motor Co., Dearborn, Mich. Prior to this, he was a technical report writer with that same company.

The following SAE members have been elected Institute of Aeronautical Sciences officers for 1951: as vice-presidents—**RAYMOND D. KELLY,** superintendent of technical development, United Air Lines, Inc.; **WILLIAM T. SCHWENDLER,** executive vice-president, Grumman Aircraft Engineering Corp.; **EDWARD C. WELLS,** vice-president of engineering, Boeing Airplane Co.; as treasurer—**E. E. ALDRIN,** aviation manager, Atlas Supply Co.; as director—**S. PAUL JOHNSTON;** as secretary—**ROBERT R. DEXTER.**

The newly elected members of the IAS Council include **WILLIAM A. M. BURDEN,** special assistant to the Secretary of the Air Force; **ELMER A. SPERRY, JR.,** treasurer, Sperry Products, Inc.; and **E. S. THOMPSON,** manager of sales, Aircraft Gas Turbine Divisions, General Electric Co.

R. J. S. PIGOTT, director of engineering, Gulf Research & Development Co., delivered a paper titled, "Engineering Aspects of Oil Refining," at a joint regular meeting of the Instrument Society of America and the American Institute of Chemical Engineers on March 12. He was president of SAE in 1948.

E. S. MICHALCZYK, formerly a senior mechanic, line maintenance, American Airlines, Inc., maintenance department, Chicago Municipal Airport, has been transferred to the Los Angeles Station of American Airlines.

WARREN F. KALKSTINE now holds a position in the Gas Turbine Unit of the Boeing Airplane Co., Seattle, Wash. He was formerly a project engineer in charge of transportation engines with Continental Motors Corp., Muskegon, Mich.

ALLEN W. ROMIG, previously a layout draftsman "A" with Piasecki Helicopter Corp., Morton, Pa., now holds the position of aircraft designer with the Harper Engineering Co., Allentown, Pa. He is working at Lockheed Aircraft Corp., Burbank, Calif., in a powerplant group as a "B" designer on the Constellation.

J. F. AUSTIN is head of the new Oil Filter and Industrial Sales Division of DeLuxe Products Corp., LaPorte, Ind. Austin was formerly representative of the DeLuxe organization in the Southwestern area. The purpose of the new division will be to strengthen and expand the DeLuxe Oil Filter service to users of vehicle and stationary gasoline and diesel engines in the oil producing, cotton, lumber and industrial fields.

The following SAE members have been elected trustees of The American Society of Body Engineers at the annual election in Detroit on Jan. 17. **I. LOUIS CARRON,** Carron Co.; **LYNN A. FILL,** Motor Products Corp.; **WILLIAM K. NORWICK,** Fisher Body Division, GMC.

LOREN E. BARTLING is now a manufacturer's agent with the Gre-Sen Mfg. Co., Minneapolis, Minn. Prior to this, he was a research engineer with Dearborn Motors Corp., Birmingham, Mich. He is engaged in sales engineering in hydraulic equipment, covering Illinois, Indiana, Ohio and Michigan.

JOHN J. DEVLIN, formerly an experimental carburetor engineer with the Eclipse Machine Co., Elmira, N. Y., is presently a machine designer with Bethlehem Steel Co., Bethlehem, Pa. His new position entails the design of heavy presses, shears, and hydraulic equipment.

W. B. BURKETT is now employed by McCulloch Motors Corp. as assistant chief engineer. He was previously with the West Bend Aluminum Co., Hartford Division, Hartford, Wis., as a project engineer.

ARTHUR C. GILBERT is presently engaged as chief vibrations engineer with the T. R. Finn Co., Bronx, N. Y. Prior to this, he was employed by the Piasecki Helicopter Corp., Morton, Pa., in the capacity of vibrations engineer.

WALTER B. MILLS, previously a technical writer with Ford Motor Co., Dearborn, Mich., is now research laboratory analyst "A" with Boeing Airplane Co., Seattle, Wash.

CHARLES J. GREGOROVICH now holds a position in the engineering department of Economy Pumps, Inc., a division of the Hamilton-Thomas Corp., Hamilton, Ohio.

A. E. KRAUS is presently district manager of equipment sales with the Champion Spark Plug Co., Chicago. He was previously equipment engineer with that same company.

JOHN H. KINSLEY is now employed in the apparatus department, Engineering Division, Aviation Section, General Electric Co., Schenectady, N. Y., as a field engineer. Formerly, he was employed by Ford Motor Co.

PARKER E. HOLT, who, prior to this was assistant product engineer with the Bunting Brass & Bronze Co., Toledo, Ohio, is presently a sales engineer with that same company in Indianapolis, Ind.

JOHN E. LONG now holds a position on the engineering staff of the Boeing Airplane Co., Seattle, Wash. He was previously a project engineer with the Challenge Machinery Co., Grand Haven, Mich.

PAUL E. HAISS, formerly with the Maintenance Division, Department of the Army, European Command, as an inspector of heavy engineering equipment, is now an engineer with the Engine Division of the National Supply Co., Springfield, Ohio.

FRANK S. BRYAN is now a fuel and lubricants engineer with Standard Oil Co., Pasco, Wash. Prior to this, he was a salesman with Standard Oil in Lewiston, Idaho.

J. L. FRANK, JR., is now assistant general manager with Graco, Woodland, Calif. He was previously service manager of Bemiss Equipment Corp., Richmond, Va.

LT.-COL. W. A. McCUTCHEON, staff member for motor equipment management in the Executive Office of the President of the United States, and Chairman of the Interdepartmental Motor Equipment Committee, has been recalled to active duty by the army. He has been granted a military furlough by the Bureau of the Budget. Colonel McCutcheon served overseas in World Wars I and II, and is currently assigned to the maintenance branch of G4.

HOWARD N. CLARK, formerly district manager of National Motor Bearing, Inc., in Cleveland, is presently assistant sales manager with the Beemer Engineering Co., Philadelphia, Pa.

SAE members who will present papers at the Institute of the Aeronautical Sciences Third International Conference with The Royal Aeronautical Society of Great Britain in Brighton, England, Sept. 3-14, are: **L. P. COOMBES**, Council for Scientific and Industrial Research, Australia, "Research with Laminar Flow Gliders;" **GEORGE BRADY**, Curtiss-Wright Corp., "Propellers for High-Speed Aircraft;" **JEROME LEDERER**, The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University, "Flight Safety."

L. A. MAJNERI is now president and chief engineer of Aeroguild, Inc., Detroit, and is engaged in the field of aircraft hydraulics and high precision products and parts. He was formerly with the Warner Aircraft Corp., where he was responsible for the development of its hydraulic products. The new company carries on his interim developments in the field.

HERBERT H. BOWIE is now an Ordnance engineer specializing in fuels and lubricants with the Fuels and Lubricants Section, Office, Chief of Ordnance, U. S. Army, in Washington, D. C. Prior to this, he was an automotive engineer in the Automotive Laboratory, Development and Proof Services, Ordnance Corps, Aberdeen Proving Ground, Md.

SAE members who spoke at the first day's session of the Lubrication Committee of the American Petroleum Institute's Division of Marketing spring meeting in Detroit, April 9 and 10, include **E. L. HARRIG**, service director, Chevrolet Division, GMC, and **H. L. MOIR**, assistant manager, retail division, The Pure Oil Co., Chicago.

WILLIAM STOCKING, who has served as field engineer in Southwestern California with the Fram Corp., Providence, R. I., has been made assistant sales manager in the Jobber Division in the Pacific Coast Zone.

HUGH MORGAN GARRETT has been promoted to project engineer in charge of the Engineering Planning Section of the engineering department of Wright Aeronautical Corp. He was formerly assistant project engineer with that same company.

WALTER G. BAIN is now a brigadier-general with the U. S. Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. Prior to this, he was employed by the Ladish Co., Cudahy, Wis., as general production manager. He is Chief of the Quality Control Division, and establishes and maintains surveillance over plans, programs, policies and procedures for the quality control and acceptance of material for the Air Force.

WILLIAM N. GROVES is on military leave of absence from Shell Oil Co., Inc., Wood River, Ill., and is stationed at Camp Breckinridge, Ky.

T. E. BOKEMEIER is now executive vice-president of the Tractor Training Diesel Institute, Portland, Ore. Prior to this, he was director of the Placement Advisory Service with that same company.

HAROLD S. VANCE, president and chairman of the board of Studebaker, has received a special honorary award from the National Conference of Christians and Jews "for his demonstrated belief in the work for which the National Conference stands". The award was presented at a dinner at the Indiana Club in South Bend on May 23. Other SAE members who previously have received similar awards include **CHARLES E. WILSON**, president, General Motors Corp., and **HENRY FORD II**, president, Ford Motor Co.

R. KAREY is presently an industrial specialist with Marietta Area Office FWAFPFO, Marietta, Ga. Prior to this, he was employed by the Friez Instrument Division, Bendix Aviation Corp., Towson, Mo.

DALE S. GRONSDAHL, who, prior to this, was district representative for the Caterpillar Tractor Co. in Alabama and Tennessee, now holds a similar position with that same company in Pennsylvania and New Jersey.

GEOFFREY GILBERT is now a consultant with Chavannes Industrial Synthetics, New York. He was previously vice-president and treasurer of General Ozone Corp., Chicago. He is engaged in the development of equipment for the production of vinyl films and sheets, and vinyl monofilaments for fabrics such as automobile seat covers.

C. M. O'DONOHOE has resigned his position with Lockheed Aircraft Corp., and since that time has been with the U. S. Department of Commerce, National Production Authority, Los Angeles district office. He is heading the Construction Section for administration of N.P.A. order M-4, regulating and controlling building construction in the 10 southern California counties.

HAROLD W. DELZELL, section manager, field engineering department of The B. F. Goodrich Co., Akron, Ohio, tire division, has been elected president of the Tire and Rim Association, Inc. Delzell, with Goodrich since 1917, is a graduate of Michigan State University. The Tire and Rim Association, which Delzell will head for the next two years, has its headquarters in Akron. The organization was founded by tire and rim manufacturers in 1903, and is the technical standardizing body of the tire and rim industries.

WILLIAM J. BEELER has been promoted from layout draftsman "B" to research engineer with the Ford Motor Co., Dearborn, Mich.

RALPH R. TEETOR, president of Perfect Circle Corp., Hagerstown, Ind., right, is shown pinning a diamond pin on the lapel of **RUFUS P. AUSTIN**, left, for completing 25 years of service with the company. At the present time, Rufus is assistant sales manager of the firm's manufacturer's sales department with offices in Detroit.

OBITUARIES

JOHN J. WALLBILLICH

John J. Wallbillich, manager of planning and development for Adam Opel, A. F., German operations of the GMC Overseas Division, died March 13, in Russelsheim, Germany. He was 64 years old.

Born in Germany, Wallbillich came to the United States three years later. From 1923 to 1934, he headed the Fisher Body tool and die department, and in 1935 went to Germany as superintendent of the press and die shop of the Opel works. Returning to this country in 1939, he served as director of Fisher Body ordnance specialties and machine section during World War II. In 1948 he was sent back to Opel as an executive.

He was a member of Union Masonic Lodge, King Cyrus Chapter, Detroit Commandry No. 1, Knight Templar, and Moslem Temple Shrine.

HAROLD G. CARRON

Harold G. Carron, pioneer in the automotive battery business in Detroit, passed away March 15, after a brief illness. He was 60 years old.

Carron was executive manager in Michigan for the Electric Storage Battery Corp., Philadelphia. He was born in Detroit, and received his B.A. degree from the University of Detroit in 1910. He had been with Electric Storage Battery since 1910.

J. RUSSELL WINCH

J. Russell Winch, personnel and public relations director of the Lubrizol Corp., Cleveland, died March 14 in that city. He was 59 years old.

Winch was born in Doylestown, Ohio. Before going to Lubrizol, he had been employed for 11 years by the Firestone Tire & Rubber Co. Winch was associated with Lubrizol for 20 years in sales, personnel and public relations. He was a member of the National Petroleum Association, the Cleveland Personnel Association, the Acacia Country Club, the Euclid Exchange Club, and the Wickliffe Chamber of Commerce.

CHARLES E. LUCKE

Dr. Charles E. Lucke, 74, head of the mechanical engineering department at Columbia University for 33 years, died March 25 in St. Louis Hospital, after a brief illness.

An authority on thermodynamics, Dr. Lucke was author of four books and more than 75 papers on this subject. He was also an authority on internal combustion engines and held 130 patents.

After his retirement from Columbia in 1941, Dr. Lucke, as Stevens professor emeritus of mechanical engineering for a decade, continued to give special lectures at Columbia, and remained as consultant to a number of business concerns and government agencies.

Born in New York, Dr. Lucke received his bachelor's degree from the College of the City of New York in 1895, a Master of Science degree from New York University in 1899, and a Doctor of Philosophy degree from Columbia in 1902. He joined the Columbia staff that year and remained on the faculty for 39 years, becoming full professor and head of the department in 1908, and Stevens professor in 1929.

During 47 years, Dr. Lucke also was consultant to the U. S. Department of Agriculture, International Harvester Co., Worthington Pump and Machinery Corp., the New York State Transit Commission, Yale & Towne Co., United Aircraft Corp., and the National Advisory Committee for Aeronautics.

FRANKLIN R. HIGHT

Franklin R. Hight died of a heart attack on March 28 in Miami, Fla. He was plant manager of the Atwater plant of the Budd Co., Philadelphia, Pa.

Hight started working for the Budd Co. in 1923, and went to the Detroit plant in 1927 as a master mechanic. He subsequently became assistant works manager and finally plant manager. He had been a member of the Shrine, Detroit Athletic Club, and the Grosse Pointe Yacht Club. He was 57 years old.

STUDENTS ENTER INDUSTRY

LOUIS J. CYR (University of Wisconsin '50) to Buda Co., Harvey, Ill.

THOMAS A. THOMPSON (Aeronautical University '50) to North American Aviation, Inc., Columbus, Ohio.

JEROME JACOBSON (University of Illinois '50) to Department of the Navy, Bureau of Ships, Washington, D. C.

TRUMAN F. BARBIER, JR., (Michigan College of Mining & Technology) to Barbier & Dulmage, Inc., East Detroit, Mich.

JAMES A. OEDER (Oregon State College '50) to General Electric Co., Portland Ore.

GEORGE P. KOCH (University of Illinois '51) to Allis-Chalmers Mfg. Co., Springfield, Ill.

FREEMAN P. MILLARD (California State Polytechnic College) to Wagner-Morehouse, Inc., Los Angeles.

JOHN WALDROP KENNEDAY (University of Florida '50) to Humble Oil and Refining Co., Houston, Texas.

RICHARD J. PRITZLAFF (University of Wisconsin '51) to Central Foundries Division, Saginaw Malleable Iron, GMC, Saginaw, Mich.

DUTCH J. ZIGICH (California Polytechnic State College '50) to Mare Island Naval Shipyard, Vallejo, Calif.

PAUL E. JOHNSON (Bradley University '50) to Richards-Wilcox Mfg. Co., Aurora, Ill.

R. B. TAMBOLI (Rensselaer Polytechnic Institute) to A. V. Roe Canada Ltd., Toronto, Ont.

WILLIAM E. FUNSCH (University of Oklahoma '51) to Seagrams and Sons Inc., Louisville, Ky.

DAMON D. PHINNEY (University of Massachusetts '51) to Westinghouse Electric Corp., East Pittsburgh, Pa.

WAYNE LLOYD (University of Florida '51) to Westinghouse Electric Corp., Pittsburgh, Pa.

UGO VOLPI (College of the City of New York) to Boeing Airplane Co., Seattle, Wash.

ELDRED LAWRENCE ELLESTAD (University of Wisconsin '51) to J. I. Case Co., Racine, Wisc.

VICTOR JOHN TOMSIC (University of Colorado '50) to E. I. DuPont de Nemours & Co., Deepwater, N. J.

PETER KULKA, in the April issue, was erroneously stated as being employed in the Engineering Experiment Station, The Pennsylvania State College, after graduating from that same college in 1951. He is with General Electric Co., and at present assigned to their Lockland, Ohio, plant.

SAE Section Meetings

Reports Findings Of Dust Tunnel Tests

• Southern New England Section
Robert E. Johansson, Field Editor

April 5—**William S. James**, vice-president of engineering and research for Fram Corp., found members of this Section deeply interested in the results of the Fram dust tunnel tests of oil filters and carburetor air cleaners. As he spoke on this subject and described the details of the testing procedure developed at Dexter, Mich., one could not but marvel at man's ingenuity in duplicating Mother Nature's dust storms.

To automobile manufacturers who of necessity must know where protective devices are most needed and where the point of diminishing returns is met, the activities of the Fram tunnel play an important role. The accelerated testing program enables studies to be made in a few short hours which would normally require thousands of miles of road travel and hundreds of hours of driving. Furthermore, conditions in the tunnel prove to be much more reliable with regard to duplication. In this respect, man has improved on Nature in the interest of good motoring and economical operation.

Results of Efforts

As the story unfolded, James demonstrated easily that the painstaking efforts of these engineers were paying off in many ways. Using specially screened grades of dust costing up to $5.00 per lb, many of the detrimental results of dust infiltration into the carburetor air stream are observed; however, the prime function of ascertaining means and methods of filtering out these damaging particles is accomplished with the facilities at hand. An improved product is possible, a filter-conscious automobile manufacturer is enabled to make cost-saving decisions, and the public is benefited through trouble-free motoring by the results emerging from the Fram tunnel.

The fact that dirt doesn't wear out and is as abrasive on the second trip through the engine as on the first accounts for oil filter needs; however, money spent on a good carburetor air cleaner is more amply repaid than money spent on any other protective filter device, in the opinion of the speaker.

In the discussion period following the talk, many interesting sidelights were revealed in this subject of dust and its control. For instance, although dust does not wear out, it does wear. Samples from the Phoenix area wore the least, samples from Idaho wore the most, and others from the Milwaukee area showed intermediate wearing qualities. It tended to point up the adage that where plows wear out first, engines wear out first.

Stewart McCargo of the Connecticut Railway and Lighting Co. substantiated the claims for good air filtration in disclosing findings of his company on faulty air cleaners. In rear engine buses operated by the company, either gasoline or diesel types, it was found that a ring gap wear of 0.250 in. was obtained in only 3000 miles of operation when a faulty air cleaner was in use. On a good setup, 80,000 miles of operation was an average occurence with 100,000 miles frequently obtained. This experience was derived in over 58 million miles of fleet operation in the New England area.

James pointed out that traveling for only five miles behind a truck on a detour often is equivalent to traveling 5000 miles on a highway; however, highway dust is also an engine destroyer. He described a test made by a concern which called for one car to travel in front of a truck and another car to travel behind it from Chicago to St. Louis and return using the highways available. The measured engine wear was twice as much for the car traveling behind the truck as it was for the car preceding the truck down the road.

Details Phases of Bearing Production

• Mohawk-Hudson Group
Donald C. Peroutky, Field Editor

March 14—The bearing manufacturer is importantly responsible for the remarkable performance characteristics of the modern internal combustion engine, according to **Richard J. Schager**, assistant chief product engineer of Cleveland Graphite Bronze Co. Addressing a joint meeting of this Group and the RPI Student Branch, Schager presented the problems involved in design, installation, and manufacture of sleeve bearings, and illustrated the last phase of his talk with a motion picture.

Conventional tin or lead base bimetal alloys have long been used as bearing materials, he said, because they offer the best surface action between bearing and journal. However, the modern automotive engine, requiring increased unit bearing loads, has necessitated the development of such materials as bronze, copper-leads, cadmium silver, cadmium nickel, aluminum, and silver. Although these materials showed increased fatigue resistance, reduced surface quality resulted.

Further development revealed that

Mohawk-Hudson Group members shown with RPI Student Branch members at the March 13 joint meeting. Left to right: Chairman Frank Baker; John Martin, RPI; Speaker R. J. Schager; John Hill, RPI; and Program Chairman Martin Berlyn

the fatigue life of tin and lead base babbitt materials could be materially increased by reducing babbitt thickness. This resulted in the micro babbitt bearings with as little as two to five mils of bearing material. Further advances were made with the introduction of the trimetal bearing containing a steel back with a thin babbitt overlay on an intermediate layer of bearing material.

The movie following the talk showed bearing manufacture at Cleveland Graphite Bronze by both the centrifugal casting and continuous steel strip casting processes. It emphasized the accurate control of quality maintained in the mass production of precision sleeve bearings.

Held on the RPI campus in Troy, this meeting was well attended by members of both sponsoring groups.

Ladies' Night Features Talk on Automobile Styling

• Pittsburgh Section
H. K. Siefers, Field Editor

March 27—Ladies' Night was reinstituted at this meeting after a lapse of about 10 years and the wives of members attended the presentation of a technical paper. Of particular interest to the ladies was the subject, "Fashion and Function in Automotive Styling," presented by **Willys P. Wagner** of Ford Motor Co.'s styling department. Wagner emphasized that in the final analysis the customer is the actual stylist. It is the motoring public that determines what the trend is to be in automotive styling.

Wagner said that by many surveys the automotive stylist knows that the public wants a 6-passenger automobile even though the space is not always being used. The car must be well proportioned, and have an appearance of fleetness in addition to being serviceable. These features must be incorporated in the car in such a way that it can be well engineered and manufactured within the limits of mass production facilities and sell at a price within the range of the prevailing market.

Speaker Willys P. Wagner of Ford Motor Co. (left) with Technical Chairman C. J. Livingstone, at Pittsburgh Section's March 27 meeting

By means of slides, Wagner showed the various stages that a new model must go through before it can be placed in production. From the many initial sketches prepared to depict the desired characteristics of the car exterior, $\frac{3}{8}$-size clay models are constructed. The most promising of these are then prepared in full-size clay models which are complete in detail and are made to resemble the final sheet metal product as closely as possible.

At the same time that this development work of the car exterior is being conducted, a similar program with respect to the car interior is being worked on. Full-size clay models of instrument panels, garnish moulding, seats and all interior appointments are prepared.

The final step consists of the construction of a full-scale wood and metal model which incorporates both the exterior and interior designs into a mockup which, appearance-wise, is a finished automobile.

The many questions asked of the speaker during the discussion period, particularly by the ladies, were convincing evidence of the success of this type of meeting.

Inspect Airline Maintenance Shops

• Washington Section
Louis Reznek, Field Editor

March 20—This meeting combined an inspection trip of the maintenance shops of Capital Airlines at Washington National Airport and an after-dinner meeting in which the maintenance operations were explained. Inspections and explanations were handled by M. S. Beyer, assistant to the vice-president; R. L. Wageneck, manager of maintenance; and Lan H. Caldwell, chief engineer.

The shop tour covered engine tear down and inspection, engine rebuilding, test cell operation, and many other points. The members were impressed by the rigid maintenance schedules as well as the detailed nature of the inspection and the exacting standards of aircraft maintenance. The final part of the tour showed a Lockheed Constellation going through its 270 hr check.

At the meeting, members learned that about 15% of gross income is spent on maintenance, and that maintenance is performed almost entirely on an operation-hour basis. Planes operate about an average of 10 hr per day and cover about 2500 miles daily. The inspection schedule averages about eight man-hours per day with a secondary inspection every week which takes 16 man-hours. Every 16-hr of operation there is a 200 man-hour inspection, and every 270 hr a 600 man-hour inspection. At 1000 hr, there is an even more rigid inspection, and at 9000 hr, every structural part is removed and all moving parts replaced.

It has been found necessary to replace or retread tires after about every 450 landings; plugs are replaced after about 160 hr. Oil changes vary with type of plane and engine. It was explained that one of the major operational difficulties is ice on wings and fuselage. In fact, a standard part of the pilot's equipment on DC-3's is a putty knife to remove windshield ice in flight.

Reports on Recent Gas Turbine Developments

• Kansas City Section
R. W. Laing, Field Editor

March 13—Approximately three-quarters of the total horsepower produced in a turbojet engine is converted to drive the compressor and its associated accessories, said **Richard T. Nalle**, manager, application engineering and order service, gas turbine division of Westinghouse Electric Corp.'s Kansas City Division.

For instance, he said, of 12,000 hp available from a turbojet engine, 9000 hp is converted to use within the unit, and 3000 hp is left for thrust. Each blade in the turbine has to be capable of handling 125 hp.

Soon after Pearl Harbor in 1941 the Navy asked Westinghouse to develop a gas turbine because of their experience in blades as applied to steam turbine work. In 1944 Westinghouse produced the 19A engine which was mainly a booster unit and was slung under a Navy Corsair plane. The J-40, not yet in production but fully developed by Westinghouse, is classified as the world's most powerful jet engine.

The J-34 turbojet is now being produced in Kansas City. This engine is 2 ft in diameter, 10 ft long, and weighs 1200 lb. It has a 3-bearing motor shaft. The starter turns over at 1500 rpm. The idle speed is 4000 rpm and the top speed 12,500 rpm.

The air oil cooler in the front of the engine is made of aluminum, but present plans call for conversion to a liquid cooler because the high speed of the plane causes friction heat. The compressor has a 4:1 ratio with the forged

blades made of stainless steel. The housings are aluminum or magnesium in the front sections but stainless steel in the rear due to the high temperatures.

The diffuser manifold section has fuel injected through nozzles in two rings; the fuel is ignited by two spark plugs; a governor controls the fuel pump according to the desired speed of the plane. The flame temperature is approximately 3000 F, but it is brought down to 1500 F at the turbine. The turbine section consists of two stages with stationary blades directing the flow onto the rotating blades correctly. The turbine blades are made of stellite (cobalt base) and are cast by the lost wax method. The roots are of a Christmas tree design for mounting. The combustion basket is now made of 25-20 stainless steel.

The J-34 engine develops 3300 lb of thrust. At 375 mph, 1 lb of push equals 1 thrust hp.

At low speed, Nalle said, the propeller type of engine is more efficient, but beyond 500 mph the turbojet comes into its own. The turboprop engine, by the use of another shaft connected to the turbine, utilizes the 25% power to drive a propeller; this type of engine operates best at a moderate speed and altitude, thus fitting into the picture best at conditions between the reciprocating type of engine and the turbojet engine.

The speaker reported that the J-34 engine powers the McDonnell Banshee (600-plus mph); the Douglas Sky Night, F-3D, all-weather plane (600 mph plus); the Lockheed XF-90 Penetration fighter (700 mph plus); the McDonnell Voodoo, XF-88, Penetration fighter; and the Chance-Vought Cutlass, F7U-1, for Navy shipboard use.

The pointed nose and swept-back wing design of the fastest planes now being produced are necessary for sonic speeds or faster because below the speed of sound the plane telegraphs its coming by pushing air up ahead of it. At the speed of sound or faster there is no telegraphing of the coming so the needle nose is necessary to pry its way through the air.

Afterburners are being developed for use with the turbojet engines. These afterburners, or ram jets, utilize the exhaust velocity of 1200 mph from the jet engine proper. Afterburners use twice as much fuel as a normal jet. Temperatures run 3500 F in the burner and 2000 F out of the exhaust.

No special fuel is needed in a jet engine as long as the fuel gives heat. The need is for a fuel with the greatest heat content per cubic foot.

Slides were used to show most of the above points and the meeting concluded with two movies—one on the new McDonnell Voodoo F-88 Penetration fighter and the other on operation of the McDonnell Phantom from a Navy Aircraft Carrier (the first time a jet plane was flown from a carrier).

Central Illinois Section Sponsors Student Debate

• Central Illinois Section
Harlow Piper, Field Editor

March 12—The best place for an automotive engine is in the rear, according to evidence presented in a debate between the SAE Student Branches from University of Illinois and Bradley University.

The Illinois team contended that the best location of the engine is just in front of the rear axle, and the Bradley team defended the conventional location.

The main points for the rear location of the power plant were increased safety, more visibility, better driving characteristics, added comfort and less design limitations.

Safety would be increased because more weight over the rear tires would reduce skidding. A reinforced luggage compartment in front of the driver would give as much crash protection as the present type of car has. The car also would have a lower center of gravity.

The designer would not be limited by the restrictions of the past. He has more available space between the rear wheels. The engine and transmission could be designed as one unit which could be pulled out easily for maintenance work.

The judges were E. W. Jackson, vice-president of Caterpillar Tractor Co., John Liggett, assistant chief engineer of Allis-Chalmers Mfg. Co., and Forrest Cockrell, assistant secretary and speech instructor of the Peoria YMCA.

■

The Illinois team, shown in the top picture with Faculty Adviser W. L. Hull, consisted of Ernest N. Pearson, K. D. Jefferson, Charles A. Pipenhagen, Don Cain, and George Fransen. Bradley debaters (second picture) were M. R. Bottorff, Fred Platt, Dick Tringali, and Glenn Reiders. Faculty Adviser Chester Linsky is at the right. In the picture below, Linsky and Hull are shown with Central Illinois Section Chairman John Findeisen (center)

At Peoria's Earthmoving Conference. . . .

1 Tuesday morning session (left to right): R. K. Super, Timken-Detroit Axle Co., Inc.; H. L. Rittenhouse, Euclid Road Machinery Co.; Keynote Speaker C. G. A. Rosen, Caterpillar Tractor Co.; and General Chairman J. P. Carroll, Caterpillar Tractor Co.

2 Wednesday afternoon session (left to right): E. H. Honnen, McCoy Co.; M. C. Harrison, Harrison Construction Co.; and Session Chairman R. D. Evans, Caterpillar Tractor Co.

3 Banquet speakers (left to right): SAE President Dale Roeder; Kenneth McFarland, Superintendent of Schools, Topeka, Kans.; Lt.-Col. David G. Hammond, chief, Engineering Research and Development Division, Corps of Engineers; and Toastmaster J. G. Findeisen, SAE Central Illinois Section Chairman

4 Tuesday afternoon session (left to right): Trevor Davidson, Bucyrus-Erie Co.; Lt.-Col. L. M. Hoover, Engineering Research and Development Laboratory; Robert A. Fletcher, Hyster Co.; William S. Pollard, Jr., University of Illinois; and M. G. Spangler, Iowa State College

5 Wednesday morning session (left to right): Session Chairman F. A. Grooss, Caterpillar Tractor Co.; W. I. Ford, U. S. Rubber Co.; L. W. Fox, Firestone Tire and Rubber Co.; C. W. Moss, Goodyear Tire and Rubber Co.; and R. V. Snyder, B. F. Goodrich Co.

Stimulating and Informative Program Presented at Earthmoving Conference

by Harlow Piper,
Field Editor, Central Illinois Section

April 10–11 — The Second Annual Earthmoving Industry Conference presented a stimulating and informative program to 613 representatives from 107 earthmoving machinery manufacturers, suppliers to the industry, and users of earthmoving equipment.

Nine technical papers and eight prepared discussions covered the fields of heavy-duty brakes, soil mechanics, tire and rim development, and selection of machines and methods for earthmoving contracts.

General Chairman J. P. Carroll opened the meeting in the packed Grand Ballroom of the Pere Marquette Hotel and introduced Keynote Speaker C. G. A. Rosen, consulting engineer to Caterpillar Tractor Co. Rosen traced the rich heritage of the earthmoving industry and showed how history has been shaped by roads. He predicted that the construction machinery industry will grow faster than the industrial machinery industry due to the need for new communities and to rising labor costs. The high accident rate on our roads is one of the growing pains of our civilization, but better roads will greatly reduce the rate. We are reacting to the accident problem faster than we did to the problems of the industrial revolution.

Session Chairman H. L. Rittenhouse, chief engineer of Euclid Road Machinery Co., opened the first technical session by presenting R. K. Super, chief engineer of Timken-Detroit Axle Co., Brake Division, who spoke on "Heavy Duty Brake Requirements of Rubber Tired Earthmoving Equipment." He outlined the basic brake requirements from a design, maintenance, and operational viewpoint. There is a need for better drum and lining material, he said, to meet the increased braking requirements if the trend to larger and faster hauling units is continued. Besides using brakes on all wheels, supplementary brakes such as the hydrotarder and eddy current brake should be considered.

D. K. Heiple of R. G. LeTourneau, Inc., discussing Super's paper, suggested that one way to get more braking capacity in the same space is to use the multiple disc type of brake. He described the operation of the electrotarder, which costs very little when used on electrically controlled units.

E. F. Speiden of Parkersburg Rig and Reel Co., also discussing Super's paper, described the operation of the hydrotarder. Supplementary brakes, he said, do not have to take all the load. By lowering the brake lining temperature only 100° F, brake lining life often can be tripled. The hydrotarder acts as an automatic governor on a downgrade because the capacity increases in proportion to the cube of the speed. It can not cause skidding or jack-knifing.

Chairman for the afternoon session was R. A. Fletcher, assistant service manager, Hyster Co. M. G. Spangler, professor of civil engineering, Iowa State College, in "Engineering Aspects of Soil," discussed the properties of soil as an engineering material. Properties of soil, he said, vary widely in various sections of the country, but designs and techniques of earthmoving equipment can be improved by studying soil in a scientific manner.

W. S. Pollard, Jr., instructor of civil engineering, University of Illinois, told how earthmoving equipment design could be improved by applying the principles of soil mechanics in his paper, "Soil Properties and the Design of Earthmoving Equipment." By understanding the method of soil failure and frictional resistance in loading, the designer can design equipment with greater capacity with the same power requirements. Pollard showed slides of suggested designs for scrapers using the principles that he described.

Lt.-Col. L. M. Hoover of the Engineering Research and Development Laboratory showed samples of the soil with which the Army must deal. He challenged the earthmoving industry to design a machine to mix chemicals with soil to stabilize the soil for roads.

T. Davidson, chief engineer, Development and Research, Bucyrus-Erie Co., discussed Pollard's paper. He described scraper tests using small scale models and agreed that application of the theories of soil mechanics would lead to improved performance.

Dinner Is Highlight

Highlight of the conference was the Tuesday evening banquet presided over by Toastmaster John Findeisen, chairman of Central Illinois Section. He introduced SAE President Dale Roeder who said that the free and open discussions and exchange of technical information, such as this meeting typified, is a defense weapon of unlimited strength. Our industry provides the means for a greater and better transportation upon which our economy depends, he pointed out.

Lt.-Col. D. G. Hammond, chief of the Engineering Research and Development Division, Corps of Engineers, U. S. Army, also was introduced. He said that the armed services need equipment that can be airborne, a good method of stabilizing muddy roads, and tractors that can travel at convoy speeds.

Main speaker of the evening was Kenneth McFarland, superintendent of schools in Topeka, Kans., who presented a dynamic talk on the necessity of selling our ideas, our products, and ourselves. This is a new era and needs new thinking to solve our problems, he stressed. There is a continuing need for more personnel relations in all fields, because there is a continuous parade of people growing up who must be informed.

To build good will, we must move in first and do that which must be done. Out of right policies, answers come before the problem is defined. He warned us not to become discouraged because the job of personnel relations is never finished. To build a strong business, we must do more for others than anyone else has even done, he concluded.

The Wednesday morning technical session on tire and rim development was opened by Chairman F. A. Grooss, staff engineer, Caterpillar Tractor Co. W. I. Ford, chief tire engineer, U. S. Rubber Co., presented his paper, "Se-

lection of Tires for Earthmoving Equipment for Best Traction, Lowest Rolling Resistance and Best Ground Support." He described the five types of tires used to cover all soil conditions.

"Design and Construction of Earthmover Tires" was presented by C. W. Moss, manager of Off-the-Road Tire Design, Goodyear Tire and Rubber Co. He described the various tread patterns, how tires are constructed, and the effect of speed and heat on the tires. He also described compounding and blending of natural and synthetic rubber.

L. W. Fox, manager of field engineering, Firestone Tire and Rubber Co., presented the paper "Engineering the Tire to the Vehicle." He said that it has been proven that inadequate tire equipment resulted in heavy losses. Inflation, load, speed, and road conditions should be considered in selecting a tire. He described the 5 deg bead tire which was developed to prevent tire slippage on the rim. It has reduced tube and flap problems and probably will be used for all the larger tires.

"Performance of Earthmoving Tires in Sand" was presented by R. V. Snyder, field engineer, B. F. Goodrich Co. He said the design points to consider are: using large single tires instead of duals, lower inflation, making every wheel a driving wheel, and sufficient horsepower to keep speeds above 3 mph.

D. C. Baker and F. R. Horman, A. Schraders & Sons, explained rigid and flexible valve extensions. The tire valve can be placed either in the stem or at the end of the extension, they said. External dirt and high temperatures due to braking are responsible for most of the valve problems.

W. R. Meyers, Goodyear Tire Co., discussed the 5 deg bead rim. This type of rim requires fewer parts and can be adapted for a tire requiring a flat rim.

R. D. Evans, Sales Development, Caterpillar Tractor Co., was technical chairman for the final session. E. H. Honnen, president, McCoy Co., presented his paper "Jobs, Methods and Machines for Earthmoving." To plan a job, he said, the geographic location, climatic conditions, and geological formations must be known. The size, number, and type of machines can be selected then, but they all must be in balance.

Liquid clutches and torque converters are two of the most valuable developments in power transmissions of our day. Elimination of shock and better synchronization is worth the added fuel costs. Due to the high cost of repairs and loss of operating time, the operator would rather put more money into initial investment than into repairs, Honnen concluded.

M. C. Harrison, president, Harrison Construction Co., in his paper, "Machines and Methods," said that design of earthmoving equipment can be improved to reduce the 15% of the time used for repairs. The most unpredictable factor in estimating a contract is the weather. Hidden rock and rising labor costs can also break a contractor. The contractor buys the type of machines to take care of the average job, and then tries to balance his machines to obtain maximum output.

In the discussion of the last two papers, O. C. Rollman, Allis-Chalmers, said that need for development of new equipment is not as great as for proper use of available equipment. Some of the money-losing factors for a contractor to avoid are: wrong equipment for the job, time lost in waiting to load, abusive operators who cause excessive repairs, lack of service routine, and poor haul roads.

The committee members who helped make the two-day meeting a success were: J. P. Carroll, general chairman; Roger Smith, program; Harlow Piper, arrangements; Jay Johnson, publicity, Douglas Erskine, finance; Walter McCulla, treasurer; Woodrow Kimsey, vendors' activities; and Robert Mills, secretary.

Roeder Tells Society's Role in Preparedness

• Western Michigan Section
L. W. Kibbey, Field Editor

March 13—**Dale Roeder** was guest speaker at this Section's annual President's Dinner. He spoke first of his numerous duties as president and the pleasure he is enjoying in bringing about their fulfillment. In a humorous note he mentioned that the office of SAE president was not noted for its fancy robes or badges, but more frequently for its stack of timetables. He expects to attend some 40 Section and national meetings during his term of office.

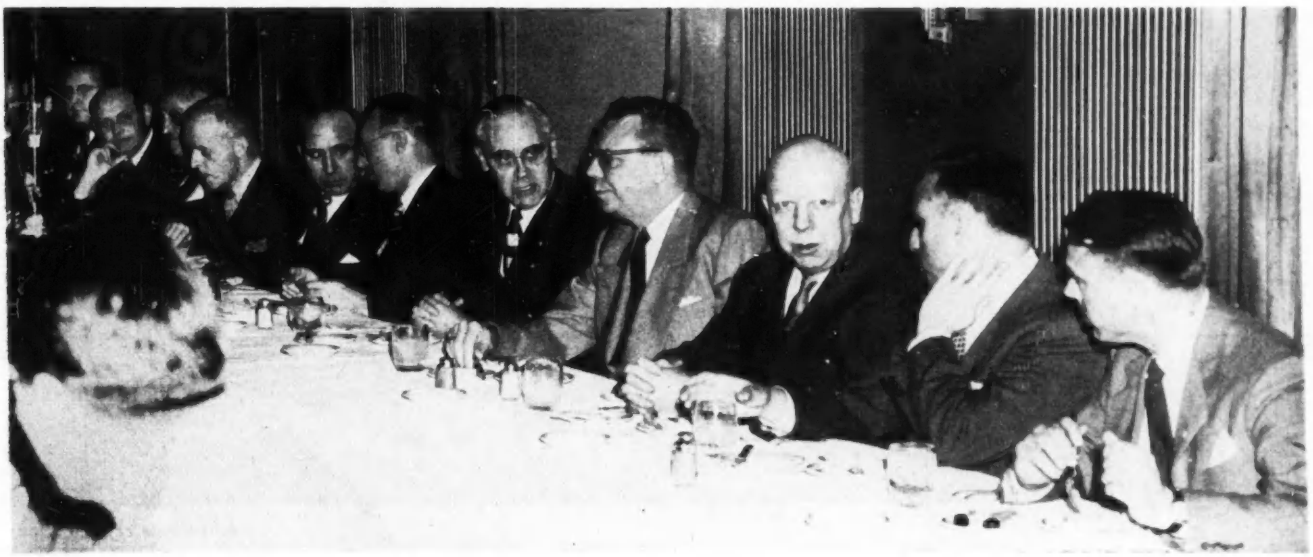
After a short recess of five years, he said, we are again expected to be the arsenal of democracy for the whole world which looks to our farms and factories for materials and foodstuffs to preserve their freedom. He emphasized that our greatest weapon and the one feared by our would-be conquerors is our strong will and ability to mass produce such goods far in access of anything that they can even approach. They have a definite edge on us when it comes to reserve manpower, but this without the materials to abet it is no definite threat.

Mr. Roeder said that we are asked to perform miracles in such critical times in order to keep our domestic economy from faltering for lack of consumer necessities while we are arming free nations of the world against a common aggressor. He believes this half-war half-peace situation can be stopped short of all-out war if we continue to use our mind-power to combat man-power through uninterrupted production of both military and home needs.

Our major wars have been won on the drafting board where mind-power has created not only the products but the necessary machines and intricate tools necessary to produce such products in volume and to high standards of quality. He spoke of the reactivating of the SAE Technical Board which is again collaborating with the various government agencies toward the conservation and substitution of critical materials. He recalled that the first SAE Technical Board held a "Preparedness Banquet" back in 1916 with 2,000 members in attendance where a program of technical assistance to the army and navy was drawn up. This group then, as at the present time, worked also toward standardization of all vehicles and equipment to minimize the service problems. About ¼ or 3,200 of our membership served the armed forces in one way or another in World War II. Many served on the War Activity Council and the War Engineering Board where technical data were provided on hundreds of items.

In regard to production Roeder says we engineers must keep our thinking flexible so as to meet sudden changes in products and/or quantity requirements. He says being "quick-change" artists is right up our alley as the automotive industry has been making major changes yearly in their product and tools for producing them which provides the necessary background and assurance to cope with changes which are constantly arising in war materials production.

In closing he stated that the SAE organization is the greatest "secret weapon" this country posesses because of its immeasurable ability to provide the necessary technical skill required to get things done in our industries. The effects of this weapon are far reaching and much more enduring than the effect of tactical weapons. He indicated that Hitler might have held Germany longer if productivity had not been set to a permanent standard because of regimentation of his technical and scientific manpower. In other words if Germany had had an organization comparable to our SAE where the individuals were free to interchange experiences, ideas, and



Shown at the speaker's table at Western Michigan Section's March 13 meeting are (left to right): C. E. Allen, president, Campbell, Wyant & Campbell Foundry Co.; Earl Ginn, executive vice-president, Continental Motors Corp.; Section chairman R. A. Snyder; R. C. Sackett, SAE Staff; SAE President Dale Roeder; Master of Ceremonies Wayne Thomas; G. W. Myers, vice-president, West Michigan Steel Foundry Co.; L. G. Matthews, treasurer, Sealed Power Corp.; G. W. Lundeen, vice-president and general manager, Muskegon Division, Muskegon Piston Ring Co.; F. J. Donovan, president, Kaydon Engineering Corp.; Dick Mock, president, Lear, Inc.; and Maurice Bolster, Shell Oil Co.

theory, we would have had a much tougher time in bringing hostilities to an end. He feels the same error exists in Russia today and if so, we can be sure to keep pace well ahead of her in production and developments.

The meeting was a tremendous success with 175 members and guests in attendance. The dinner was proceeded by a cocktail party sponsored jointly by the Shell Oil Co. and the Muskegon Piston Ring Co.

Says Most Russians Don't Want War

• Milwaukee Section
E. L. Conn, Field Editor

April 6—The "Production Potential" of the United States is probably the one factor which Russia fears most, **A. T. Colwell**, vice-president of Thompson Products, Inc., stated from his first hand observations of conditions in Europe. The United States is the one country in the world that has realized the tremendous advantage of building up additional sources of supply and has thereby enjoyed the ability of being able to rapidly expand production.

In addition to the "Production Potential," Russia fears other things such as the atom bomb, the B-36 bomber, lack of oil supply, and internal disloyalty. Colwell pointed out that this internal disloyalty could be influenced importantly by this country. While he agreed that the next two years in the timetable of a strong defense program will and should be aimed at rearming the United States, we should not rely entirely upon rearming. The greatest ally available to this country, Colwell believes, are the millions of non-Communist Russians who are not interested in war—especially if they could be informed of facts.

Colwell then discussed the defense program at some length with particular emphasis upon aircraft equipment, and made comparisons of British developments with our own as well as Russian developments.

Several slides were used to illustrate jet engine developments and the important position that jet engines have assumed as indicated by results in the Korean conflict. Also, the costs of present day aircraft were compared with costs of aircraft as produced at the end of World War II.

In answer to questions after presenting his talk, Colwell pointed out that much of the data on Russian developments is very sparse and in many cases it is necessary to suspect what they may have developed. As to what percent of Russian technology is due to the inheritance of German talent, Colwell said that he could not guess but that many copies of British or American equipment were found with some good improvements.

Some discussion centered about the comparative advantages of centrifugal compressors versus axial flow compressors. The major advantages of the centrifugal compressor, he said, are its lower cost and ruggedness. The axial compressor with its higher compression ratio is needed, however, as the power requirements increase.

Speaking of the astounding increase in costs of military aircraft since 1945, Colwell said the increased costs were mainly because of the use of electronic controls for flying the craft as well as for control of gunfire.

Colwell, an SAE past-president, was introduced by Past-President C. E. Frudden.

Truck-Highway Problem Needs Careful Planning

• British Columbia Section
J. B. Tompkins, Field Editor

March 12—Vehicle length is a definite factor in highway design. Because highway engineers "must look into a crystal ball in an effort to determine highway design policies which will meet present needs and provide for vehicle requirements 20 years hence," it is essential that "an economic balance between vehicle sizes and weights and the required highway plant be factually determined."

Fast-talking automotive engineer **Wallace Linville** of San Francisco's Western Highway Institute reminded his audience of SAE members and highway transporters that "size has become a primary consideration for vehicles used to haul general freight

Continued on Page 87

Aerial view of the campus

SAE AT

BRITISH COLUMBIA

When SAE student activity at the University of British Columbia began in 1947, the 10,000 enrollment at the University already was sponsoring a tremendous number of extra-curricular student organizations. But the SAE Branch grew rapidly, and passed the 70 mark last year.

During the first year, students had to rely a good deal on speakers who could be persuaded to come out to the University either before or after speaking to British Columbia Section. Outstanding feature of that year's program was a student-sponsored meeting held in Vancouver's Hotel Georgia, with Section members as guests and BCU's Professor J. R. W. Young as chairman. Two engineering students discussed problems in British Columbia's basic agricultural and pulp and paper industries. One spoke on power spraying and dusting, herbicides and fungicides; the other gave an account of investigational work done on the Alberni Canal (on Vancouver Island's west coast) before installation of a pulp mill. Both used slides and pictures.

This year's BCU Student Branch officers (left to right): Front row: Vice-Chairman Elvin Gordon and Secretary Douglas Overhill. Back row: Program Chairman Dick Driedger and Chairman Alvin Fenton

In February of 1949, the Student Branch again was host to the Section. The meeting, held in Brock Hall on campus, was the largest in the Section's history. Section members toured the sprawling BCU campus, and saw displays and experiments in the mechanical, agricultural, and forest engineering labs, ranging from fuel and octane rating tests to experiments in quick hardening and metal fatigue.

About this time, with a membership of some 40 students, the Branch brought in many speakers of its own. Considerable assistance was lent by such companies as Firestone, Goodyear, and SKF Industries, whose representatives gave illustrated talks. When British Columbia Section was entertained at an on-campus dinner, an excellent address was given by Dr. G. M. Shrum, head of the BCU Physics Department, on "The Peacetime Applications of Atomic Energy."

This year, too, a full program has been carried out. More representatives of leading companies have been guest speakers, and a special feature was a series of RCAF films on jet engines and "Operation Muskox." The downtown meeting was highlighted by student talks by Frank Berto, Hugh Coleopy and Paul Gunby, who discussed "Increasing the Power of Mercury Engines for Racing Purposes;" "Liquid Petroleum Gas Engine Fuel;" and "Crankcase Ventilation."

Present Faculty Adviser H. W. Robinson graduated from the University in the Spring of 1950, and is now lecturing in the Agricultural Engineering Department.

Professor Young, who was faculty adviser until this year, not only heads a couple of BCU departments, but also has gained campus-wide fame as a salmon chef. Once each summer he changes his lab smock for a chef's hat and apron and heads the annual barbecue for summer students. The project begins about 10:30 with a fire started in a long pit under a huge log. Twenty-pound salmon are split into fillets, rubbed with curry powder and salt and pepper, and spread on split

alder poles. ("Oil doesn't run out this way," he says ". . . superior to the flat stone system.") By 3:30, labs, lectures and libraries are deserted as the news and smoke and delicious smell begin to reach students.

With Branch membership now past the 50 mark, the next count should add greatly to the present roster of SAE members graduated from British Columbia.

Edward Marshall Bauder (**1943-48**), Cecil Jerrold Frankovitch (**1944-49**), Ernest Douglas Grocock (**1947-50**), Harold J. Morris (**1935-40**), Edward Barry Sleigh (**1939-44**), Daynard McCall Welsh (**1944-49**).

Prof. J. R. W. Young in his annual role as "Chief Chowderhead." He learned the art of barbecue from Stanley Cut-Hand, an engineering graduate and grandson of Poundmaker, the Cree chief of Riel Rebellion fame

---

Parks College of Aeronautical Technology

Rolland L. Anderson, director of engineering and research for Chicago and Southern Air Lines and 1951 SAE vice-president representing Air Transport Activity, was principal speaker at the third annual banquet of the Parks College SAE Student Branch, on March 15. Present at this meeting were Parks College Dean Niels C. Beck; Founding Chairman of the Branch John Mylin; and first Faculty Adviser Frank Myers. Chairman Donald Kaehlert gave a short history of the Branch and its activities, then introduced Anderson.

The speaker sketched the opportunities for maintenance personnel in airlines, pointing out that the technical background of engineering men must be increased because of the greater complexity of present airline equipment and the many changes that have taken place in recent years. There is much need for standardization of equipment, he said, and closer relations between the airlines and the manufacturers would help the situation. He told of the efforts of the SAE Air Transport Activity in presenting problems to manufacturers in the way of design and safety changes.

During the question and answer period, Anderson said he believed it would be some time before jet aircraft would be put in use by the airlines because of the traffic congestion around large airports and the relatively short range of the jet and its inefficiency in low altitudes and short distances.

Parks College of Aeronautical Technology

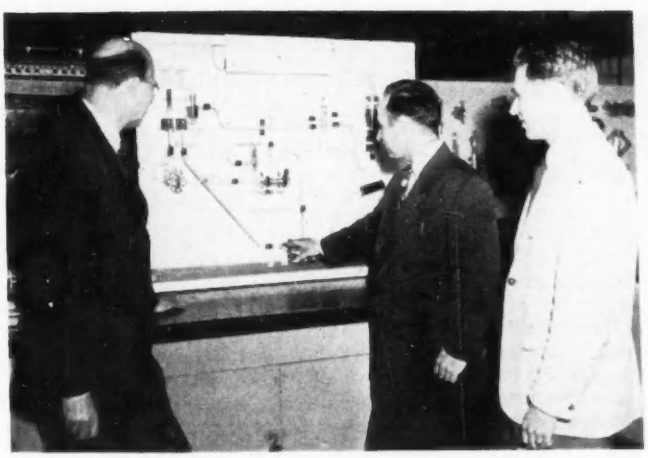
The St. Louis Public Service Co. was host to students on March 7 for a tour of the overhaul shop. Here they saw all the operations necessary to keep the large fleet of buses in operating condition. The maintenance garage handles the periodically scheduled major overhauling of all 1200 of the buses operated by the company. Students were particularly interested in the differences as well as the similarities between this kind of maintenance and the aircraft maintenance with which they are familiar.

Oklahoma A & M

On March 8, the second anniversary of the founding of the Oklahoma Power and Propulsion Laboratory at A & M, Student Branch members heard a discussion of the A & M engine being developed there.

William Burn, a widely known inventor and engineer in Great Britain who has been head of the OPPM since its establishment, described some of the diesel engines he has designed and built in England, and which formed the basis for the new engine developed on the campus. He cited many of the excellent engines here and abroad with which this new A & M engine must compete to be successful. There are many problems in design and experimentation, he said, that must be met and overcome before success will be achieved. And there is great competition from modern jet and gas turbine engines with their remarkable performance and low weight, if not fuel economy.

The A & M engine is designed as a compression-ignition engine; that is, it has no spark plugs, carburetor, or igni-



J. T. Harrington, center, faculty adviser to the Parks College SAE Student Branch, shown in the College laboratory with Hollister Moore of the SAE staff, left, and Branch Chairman Don Kaehlert. Moore visited Parks on Feb. 21

Speaker R. L. Anderson addressing the annual banquet of Parks College SAE Student Branch. At the speaker's table with Anderson are (left to right) Chairman Donald Kaehlert; Faculty Adviser J. T. Harrington; and Vice-Chairman Pat Tobin

25 Years Ago

Facts and Opinions from SAE Journal of May, 1926

Members will receive, during the first two weeks of May, copies of the 1926 SAE Handbook, the first to be printed as a complete bound volume. So, it becomes unnecessary for members to keep their Handbooks up to date, to insert new and superceding data sheets, and to check the collation periodically.

■

The Axle and Wheel Division of the Standards Committee has recommended that the present SAE specifications for wood-spokes for passenger car and motor truck wheels be cancelled, as they no longer represent current practice owing to the development of balloon tire equipment.

■

Experiments are under way, George C. Acker, Cleveland Worm & Gear Co., told the Indiana Section, to prove or disprove the possibility that the limit of load for worm gearing is set by the fatigue limits of the bronze and that "we must look to nickel bronze with its increased ductility and length of fatigue life to increase the capacity of worm gearing."

■

"Steady progress has been made in the application of superchargers of various designs to racing cars and undoubtedly it will not be long until devices of this kind are adopted as standard equipment on passenger automobiles."—C. W. Insler, General Motors Corp., Research Laboratories, in 1926 Annual Meeting paper.

■

The Ball and Roller Bearing Division recommends that the present SAE Standard for Metric Roller Bearings be cancelled, because this type of bearing has not come into general use since adoption of the standard in 1916.

A constitution for an International Standards Association was drafted last month at a New York meeting of the national standardizing bodies of 18 countries. The Association will influence to a greater or lesser extent the work of the American Engineering Standards Committee and the SAE, especially in those projects for which the SAE is a sponsor or which affect the automotive industries.

■

Following his paper on "Some Aspects of Airplane Inspections," J. J. Feeley, chief inspector, Glenn L. Martin Co., Cleveland, was asked: "Is the wing structure always riveted?"

He replied: "The wing that was shown on the screen is of all-riveted construction. Welding of the high-strength aluminum alloys into structures of this kind is not desirable if the full strength of the material is to be retained. Welding is being done to a great extent on steel structures, with success."

■

A proposed amendment to the SAE Constitution, which has been sent to voting members, would abolish the office of Second Vice-President for stationary internal-combustion engineering and substitute therefor a Second Vice-President for operation and maintenance. The amendment was proposed by J. F. Winchester at the Annual Meeting in Detroit last January.

■

"If you have no problems in your business," says C. F. Kettering, "if you are perfectly satisfied with your product, your processes and your costs in all respects . . . if you have no troubles from competition or other sources of worry and are sure you are not going to have any for years to come . . . then you **may** not need research."

tion system, and works directly with a gas turbine. Design is quite orginal and departs considerably from the conventional design of today; it is intended to have an exceptionally universal application to most industry purposes, including aircraft, automotive, locomotive, oil well drilling, and marine propulsion.

Designed primarily for economical fuel consumption (as low as 0.25 lb per brake hp per hr is expected) the A & M engine is designed to burn diesel fuel, jet fuel or residual oil.

The A & M engine is basically a two-stroke opposed-piston diesel engine with cylinders which operate at a red heat like the combustion chambers of jet and turbine engines. The liners and pistons will not have piston rings or lubricating oil as in usual practice. The same air source for charging the cylinder will be used to deliver air timed to cool the cylinder and pass the heated air to the turbines. By designing the engine along these lines the cooling losses of the A & M Engine will be cut to about 5% of the power developed which is in contrast to about 30% in the modern diesel today.

In the aircraft application, which is the hardest to design, and has been the first consideration by Burn and his staff, the A & M Engine will make use of the very high temperatures and pressures still in a diesel cylinder at the end of the stroke to drive a timed exhaust gas turbine at three or four times the engine speed. Both engine and turbines will drive multiple ducted fans and in addition there will be some jet thrust from the gas turbine outlets. When developed, the A & M engine will enable aircraft to travel three times the distance and the international consequences will be considerable.

The turbines will be so designed to take the exhaust gases from each cylinder direct from the exhaust port right into the nozzle of the turbine. This eliminates the losses inevitable when normal long passages are used to transmit the gas flow and consequently most of the exhaust energy can be put to good use. The gases will pass at supersonic speed to the exhaust turbine which will result in recovering about 30% of the heat in the fuel normally lost via the exhaust in a modern engine.

—Leo King

University of Pittsburgh

Charles W. Butler, chief automotive engineer of Gulf Research & Development Co., spoke to 45 members of the Pittsburgh Student Club on March 8 on "Automatic Transmissions." He traced the history of automatic transmission development and described in detail the units now in use by most of the automobile manufacturers.

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Continued from Page 83

and agricultural commodities." Delivering a paper originally prepared for presentation by the WHI's highway traffic engineer Edwin Mills on the "Turning Characteristics of Vehicles," Linville said that 50 ft is the minimum practical radius "for the outside front wheel adequately to accommodate all vehicle types."

British Columbia's maximum legal length is 60 ft on certain designated highways. Length on most of the Province's highway system is held down to a maximum of 50 feet. Vehicles in the 60-ft category are, in most instances, large truck and trailer combinations operated into British Columbia from U.S. points. Typical is equipment in service on the routes of Los Angeles-Seattle Motor Express, Inc., between Vancouver and Los Angeles.

Such vehicles, forerunners of tomorrow's standardized equipment on B. C. roads as general freight becomes lighter (because of plastics, aluminum, and so forth) more bulky and requires more cubic carrying space, requires at least 50 ft for the outside front wheel path. Highway engineers, Linville intimated, in planning for future traffic must provide for truck turning facilities for this minimum to accommodate today's traffic.

Tests described by Linville were conducted by the California Division of Highways in cooperation with the Western Highway Institute. WHI's interest has been sparked by demands from the trucking industry for factual data on maximum lengths feasible.

Semitrailer hookups present the greatest problems to highway designers and require the greatest turning area. Track widths on the semi rigs varied from 0.5 ft wider than other vehicle types on a 250-ft radius curve to 5 ft wide on a 50-ft radius curve. "Only the truck tractor and semitrailer need be considered in determining pavement widths required for all vehicle types", the speaker declared.

Using a semitrailer specially built with adjustable length, the California highwaymen made comparative tests with a standard van-type semi, using the same tractor in each instance. Offtracking in both cases was almost identical with the amount of "offtracking controlled by the distance from the kingpin to the rear axle of the semitrailer."

"The additional offtracking produced by truck tractor and semitrailer combinations with a distance of 31 ft from the kinpin to rear axle compared to the semitrailer combination with a kingpin to rear axle distance of 29 ft varies from 0.2 ft on a 180-deg turn with a 400 ft radius to 0.8 ft on a 180-deg turn with a 50 ft radius", Linville said. "Curves through a full

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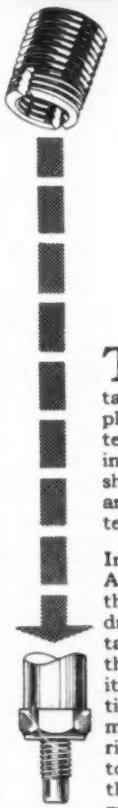

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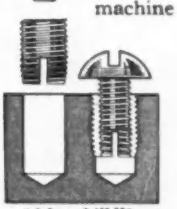

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180 deg are seldom encountered in highway design so the additional pavement width required for a truck tractor and semitrailer combination with a kingpin to rear axle distance of 31 ft would generally be considerably less than the 0.8 ft required on a 180-deg turn with the minimum 50-ft radius. The additional width required for a truck tractor and semitrailer combination with a kingpin to rear axle distance of 31 ft is insignificant".

B. C. has a maximum trailer length of 35 ft, making the 31-ft distance from kingpin to center of rear axle standard.

To prevent excessive overhand from the front end of a semitrailer on an adjacent traffic lane, the kingpin can be up to 3 ft from the front of a square front semi and 5 ft from the front of a semi with rounded corners.

Amount of offtracking is controlled by the distance from kingpin to rear axle; is not affected by the length of body. A semitrailer with a body length of 40 ft measuring 3 ft from the front of the body to kingpin and 31 ft from kingpin to rear axle would require approximately the same pavement width as the present legal 35-ft semitrailer length in B. C. (same as California).

The truck and trailer combination used in the California tests had an overall length of 60 ft, the present legal limit in California (and on certain B. C. highways). This combination produced less track width than the truck tractor and semitrailer combination, varying from 0.2 ft less on the 400-ft radius curve to 5 ft less on the 50-ft radius curve. Although a truck and trailer combination with a length greater than 60 ft was not available during the tests, a study of the turning characteristics of the 60-ft combination shows that the length of the truck and trailer combination could be increased to as much as 70 ft or more without exceeding the track width of the truck tractor and semitrailer combination.

Tells of Ordnance Standardization Work

• Buffalo Section
D. C. Appelby, Field Editor

March 15—"Latest trends in Ordnance Vehicles" was the subject of a most interesting talk by **Capt. R. C. Howard**, executive officer of the Rochester Ordnance District, Rochester, New York. Howard traced the progress being made by the Ordnance Department in standardization of equipment.

Pointing out that real progress was being made in categorization of equipment as light, medium and heavy, Howard explained that by the selection of a minimum number of basic air-cooled powerplants and chassis designs, the required inventory of spare parts had been cut as much as 70% in quantity. This program is being applied to weapons carriers, personnel carriers and armored vehicles.

Colwell Reports His European Impressions

• Southern California Section
R. E. Strasser, Field Editor

Feb. 20—The Russian people do not want war. This was the impression brought back by **A. T. Colwell**, vice-president of Thompson Products, Inc., from an extended tour of Europe, and reported to SAE members at this meeting.

Russia, he said, is a country occupied by military force, and the majority of the people are not party members. The Iron Curtain not only prevents news and information from leaving Russia, but is even more effective in preventing information of the rest of the world from reaching the Russian people. The Voice of America is doing

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something to inform the people of Russia and her satellite countries, but in Colwell's opinion it is not enough. We need, he said, a well-organized, well-paid underground in addition to a very thorough informational program —headed and staffed by top advertising and publicity men rather than politicians and amateurs. Colwell feels that a network of radio stations broadcasting to each individual group of people in their own tongues and dialects would be especially valuable. The underground should be supplied with printing materials and all other means of getting information into the hands of the people. Such a program would cost many millions of dollars, but would, he is sure, be well worth it. We must continue, he said, to rearm ourselves and be prepared for any emergency, but winning the confidence of the people of Europe and informing the people of Russia and her satellites would do much to obviate the need for using our military forces.

Announcement was made at this meeting of the Mac Short Memorial Award, to be made by the Section to the student contributing the most to engineering during each school year. To be eligible, the student must be enrolled in one of the SAE Student Branches or Clubs affiliated with Southern California Section. The trophy is to be a perpetual one upon which will be inscribed the names of the winners and retained for a year by the school of the award winner. First award will be made May 17.

Hear Latest News of Liquefied Petroleum Gas

• Chicago Section
Einar M. Comfield, Field Editor

March 13—A record crowd for a combined Truck, Bus and Rail Car and Transportation-Maintenance Group session turned out to hear the paper on the use of LP-gas presented by **A. J. St. George,** assistant branch manager of the Ensign Carburetor Co.

Sparked by the genial Fred B. Lautzenhiser and Eric W. Lager acting as co-chairmen, the meeting ran well past the usual closing time, due to the challenging paper presented so ably. Rapidly growing interest in the subject was evidenced by the question period, which brought into the discussion the equipment manufacturers, refiners, engine builders and bus and truck operators.

St. George pointed to the fact that the vast amount of LP-gas available, particularly propane and butane, now important by-products of refining and gas production, had promoted the use of these gases in many types of service.

The City of Chicago has at present approximately 170 buses so equipped now operating, with over 500 on order. Engineers of the Chicago Transit Authority were present, representing the largest users in the Chicago area of propane-driven equipment.

The speaker pointed out that the Btu content of propane is only 70.7% that of gasoline, yet under the same conditions the same engine using propane can deliver 92% of the power delivered when gasoline is used, although the specific fuel rate will be higher. The desirable characteristics of propane as fuel include its high volatility (boiling point -44 F), good mixing quality, high octane rating (125), low cost, and cleanliness.

At present no truck or bus engine has been designed specifically for propane fuel, hence some loss in efficiency is to be expected. Higher compression ratios are necessary, and some engines have used as high as 10.0 to 1. The proper ratio for any given engine

must be determined, preferably by the engine manufacturer. Combustion chamber design, spark plug location, valve and seat design, piston and ring arrangement, valve timing and port sizes must also be considered. Hot spots in the manifold are not desirable, and due to the slower burning rate of propane, special attention must be given to the ignition advance, which is not the same as for gasoline.

Cooling systems provided for gasoline driven vehicles are generally adequate when conversion is made to propane. Bearing life generally is improved using propane fuel, since there is no dilution of the lubricating oil by the fuel. For the same reason valve sticking and carbon deposits are eliminated. It was indicated that lubricating oil can be used from three to five times as long as with gasoline, without injurious effects on the engine.

With increased compression ratio, higher coil potentials are desirable. For the same reason starter loads are increased and adequate motors are important.

The parts and equipment necessary to convert to LP-gas operation were explained in detail. Units are designed for 200 lb working pressure with tank safety valve set at 250 lb. Pressure varies in full tanks from 20 lb per sq in. at -10 F to 250 lb at 100 F. Essentially, the components of the system include the fuel tank, a fuel filter, high pressure regulator, vaporizer low-pressure regulator and the carburetor.

Safety considerations were outlined by St. George, including location of tanks with ample road clearance, wheel clearance and well away from the exhaust system. Several types of excess flow-check valves and automatic shut offs are available for added safety in handling the highly volatile fuel.

The author emphasized the fact that the use of LP-gas fuels have been under development for only 20 years, while gasoline and diesel engines have had well over a half century of development.

It is not expected that LP-gas will ever be widely used as a passenger car fuel; in fact, it is not recommended for this application. However, there are specific uses where it is used to excellent advantage as in farm tractors, buses, trucks and power units and it is in these applications where its use is to be encouraged.

Interesting discussions were presented by Robert Coss, manager of the motor coach division of White Motor Co. now on loan to the National Production Authority in the Defense Transportation Division, and by Marion L. Fast of Cummins Engine Co. and George W. Grist of Phillips Petroleum Co. Questions from the floor kept the discussion lively. Altogether it was one of the best meetings of the year.

Tells Contributions Of Memorial Day Race

• Mid-Michigan Section
E. H. Holtzkemper, Field Editor

March 5—One hundred sixty members of this Section gathered at the A. C. Spark Plug Factory in Flint this afternoon for a plant trip. Guides explained the processes and operations used in the manufacture of spark plugs, air cleaners, oil filters and instruments.

In the evening the group heard **Dr. George A. Bowie** of Firestone Tire & Rubber Co. discuss the history and contributions to automotive progress of the 500 Mile Memorial Day race at Indianapolis. The oval track is 2½

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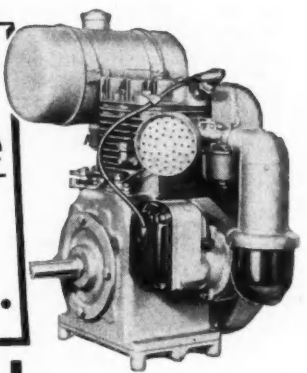

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	Model ABN	Model AKN
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Stroke	2¾"	2¾"
Piston Displ. (Cu. In.)	13.5	17.8
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1800 R.P.M.	2.5	3.6
2200 R.P.M.	3.1	4.5
2600 R.P.M.	3.7	5.3
3000 R.P.M.	4.2	5.9
3600 R.P.M.	4.6	6.2
No. of Piston Rings		4
Fuel Tank Cap.		1 Gal.
Weight, lbs.	Net	Crated
Standard Engine	76	89

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miles around. It is 50 ft wide on the straight stretches and 60 ft wide on the turns with a turn bank of 16 deg 40 min. Approximately 175,000 people crowd into the 433 acre grounds every Memorial Day to witness the race.

The contributions of the race to the passenger car business began with the first 500 mile meet in 1911 when Ray Harroun used the first rear view mirror. Other products first tested at the track and later adopted for passenger cars were balloon tires, hydraulic shock absorbers, four-wheel brakes, spherical combustion chambers, and improved steering and suspension systems.

In the discussion period Messrs. Hershey and Dybvig of Firestone explained that racing tires were inflated with dry hydrogen gas to reduce heat generation.

Cites Great Growth In Airline Facilities

• Metropolitan Section

Charles F. Foell, Field Editor

March 1—The vast postwar development of commercial aviation has given this nation a huge potential for war and for peace, according to **Ralph S. Damon**, president of Trans World Airline, before an audience of more than 110 Met Section members and guests.

When the nation was still reeling under the blow of Pearl Harbor, the scheduled airlines had available for the civilian economy only 183 airplanes, he said, whereas today these lines have more than 1000 at work—almost one-half of which are 4-engine transports. Today these lines can furnish almost 70 million seat miles per 24-hr day, or more than 25 billion seat miles a year.

"Our airlines today are able to carry the equivalent of 85% of all the intercity traffic carried by the country's railroads in 1949 on the assumption of a daily utilization of 10 hr per day," he said, "In emergencies this utilization can be increased to 12 hr a day."

"Passengers carried annually across the oceans have risen from 5,533 to 516,162 in the past 11 years," he added, "and all-air cargo grew from 542,215 ton-miles to 53 million in that period, an increase of over 90 times."

This is an indication of the achievements of the air transport industry since World War II, despite the fact that the airlines, as Damon said:

". . . came out of the War starry-eyed with ambition, groggy with fatigue and years behind the time technologically. Many people consigned us to a sort of financial hell because we leaped into an equipment race which appeared foolhardy. Although the industry was then near bankruptcy, we felt that you cannot give service unless you have the required equipment. Today, as an industry, we see the finest fleet of commercial aircraft in the world—thanks to you engineers."

Speed, which is demanded of the airminded public, is not only a matter of fast aircraft. The industry's almost-foolproof communications system has solved the reservation problem.

More careful maintenance, better scheduling, and reduction of lost ground time have all been a contribution, along with faster aircraft, in the complex solution to attaining higher speeds.

"Look at any world map. You will see great areas of wilderness . . . a wilderness of fear, poverty and ignorance.

"Some of the world's greatest cities are so populated. Yet throughout the world mankind wants to be freed from these blights.

"Only the airplane, like a great bird of legend, can fly to them and from its belly disgorge the magic tools devised by the engineer to make freedom possible. These are the machines, the engines, the plows, the pumps to give them water, the training for the brains to give them light.

"This is the role that will give real meaning to this 20th century drama.

"This is the part that, as an engineer and an employee of a great airline, I hope we all may play," he concluded.

Chairman of the meeting was Vice-Chairman George T. Hayes of the Section's Air Transport Activity.

Tour New Bus Terminal

More than 60 members and guests attended Metropolitan Section's March 8 panel meeting tour of the Port of New York Authority's new $24 million bus station at Eighth Avenue and 41st Street and the $9 million truck terminal, to inspect what was called the prototype of future highway transport terminals.

The bus terminal, a three-story, 800 × 200 ft structure covering an entire city block, handles 130,000 passengers every week day through the media of commuter service and long-haul routes. Overhead ramps from Lincoln tunnel carrying Jersey traffic are 1,500 ft long.

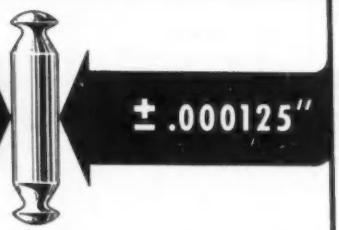
The roof, covering three acres, will accommodate more than 450 automobiles for parking. The building and ramp structures required relocating 599 residents of homes which were torn down in the area.

Nearly 50 concessions, including dining rooms and less elaborate eating places, retail stores, valet, barber and other services, a physician and a dentist, have space in the building.

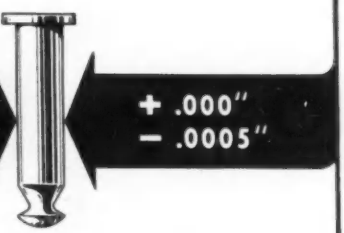
Several thousand bus movements, during the morning and evening rush hours and less frequently throughout the day, are eliminated from the streets

HIGH MACH NUMBERS
really mean—
CLOSE TOLERANCE
STRUCTURAL DESIGNS

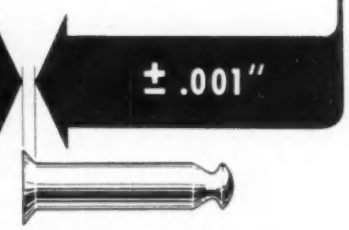
hi-shears
mean—
CLOSE TOLERANCE
STEEL FASTENERS



The dowel pin features the closest tolerance of any aircraft fastener. Precision fit, flexibility to mold to irregular surfaces and elimination of spot-facing will reduce manufacturing costs.



The close tolerance shank answers design problems where close fit (either slide or interference) is needed in critical fitting attachments. Available in minimum hardness ranges of 125,000 psi and 160,000 psi.



The close tolerance head permits smooth surfaces, essential to transonic speeds and laminar flow. Rapid installation is gained without hand fitting in either cut-counter-sunk or dimpled holes.

U. S. and foreign patents — Trademark registered

THE hi-shear RIVET TOOL CO.
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in the Times Square section of mid-Manhattan with the opening of the terminal.

Buses next took the party to the Authority's truck terminal at West and Spring Streets, where Col. Benjamin Harris explained how long-distance trucks and combinations were unloaded at one side of the 800 ft long platform and re-loaded on city delivery trucks on the other side of the platform. Outgoing merchandise is then loaded on the empty long-distance rigs for shipment outside the city; 70 loading docks each are provided for long-distance trucks and for city delivery trucks.

A crating shop is provided to re-crate packages when this service is needed.

An endless power chain at the mezzanine level hauls loaded and empty dollies to the appointed docks in providing mechanical handling of the bulk of the 14,000 to 16,000 tons of freight which are being handled daily in the 900 ft building.

Electrical and pneumatically operated communications systems act as the "brain" of the transfer and routing system which keeps the flow of freight moving evenly.

Ramps leading to and from the roof parking area permit parking of empty and loaded trailers and trucks and automobiles.

The five city boroughs, Long Island, Westchester and the area around Hackensack, N. J., are currently being served by the terminal.

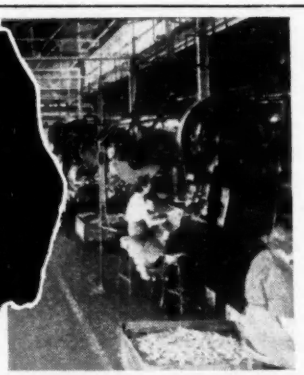
In discussing the operation, Harris predicted that such facilities are the only rational solution to the increasingly congested urban areas throughout the country.

"More facilities such as this," he said, "appear to be the only deterrent to city ordinances aimed at prohibiting loading and unloading large trucks and combinations in city streets.

"Since November, 1949, when this truck terminal was opened, we have been delivering about 95% of all freight passing through here within 24 hours of receipt."

Walter H. Langseder, Thomas J. Lipton Co., Inc., was technical chairman of the meeting, which was arranged for by William Bean and Robert Gardner, the Section's Vice-chairman for Transportation and Maintenance.

toledo stamping's
FACILITIES FOR
SUB-CONTRACTING



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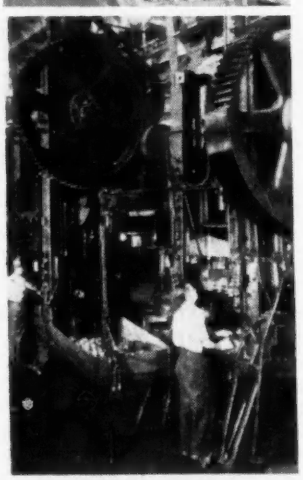

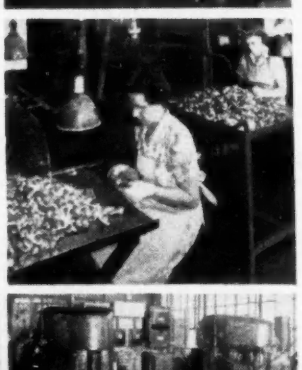

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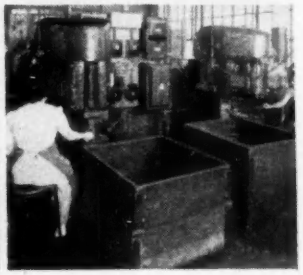

Reports Features of Powerglide Transmission

• New England Section
C. G. MacDermot, Assistant Field Editor

March 6—Two air brake movies and a talk on Chevrolet's new automatic transmission were features of this meeting.

The films, provided by William F. Mahan of Bendix Westinghouse Automotive Air Brake Co., showed the operation of an air brake system from a simple two-axle truck installation to one on a tractor with semi and full trailer.

R. S. Plexico, head of Chevrolet's transmission group, brought slides as well as several important parts of the Powerglide automatic transmission to supplement his talk. Although Chevrolet has been exploring ideas for an automatic transmission since 1941, he said, the torque converter now used was not considered until recent improvements in production indicated that its cost in large numbers might be made consistent with Chevrolet's requirements. Chevrolet now makes almost the entire unit out of steel stampings. The spot-welded subassemblies fit together accurately and are then brazed in a furnace. Many other parts also are made from stamp-

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"FIRST IN THE FIELD OF FILTERING"

ings, including the planetary cages.

Among Powerglide's features, Plexico said, are:

1. It can be assembled and fully tested, then shipped and installed as a unit in the chassis with no further adjustments required during installation;

2. It can be serviced by the regular service organization, and filled from under the hood;

3. To save power consumed by the transmission, cooling is thermostatically controlled; if oil temperature reaches 240 F, oil is by-passed to an oil cooler which replaces the elbow in the engine lower hose connection. Heat is absorbed by the engine coolant. The operating oil pressure is controlled by engine vacuum;

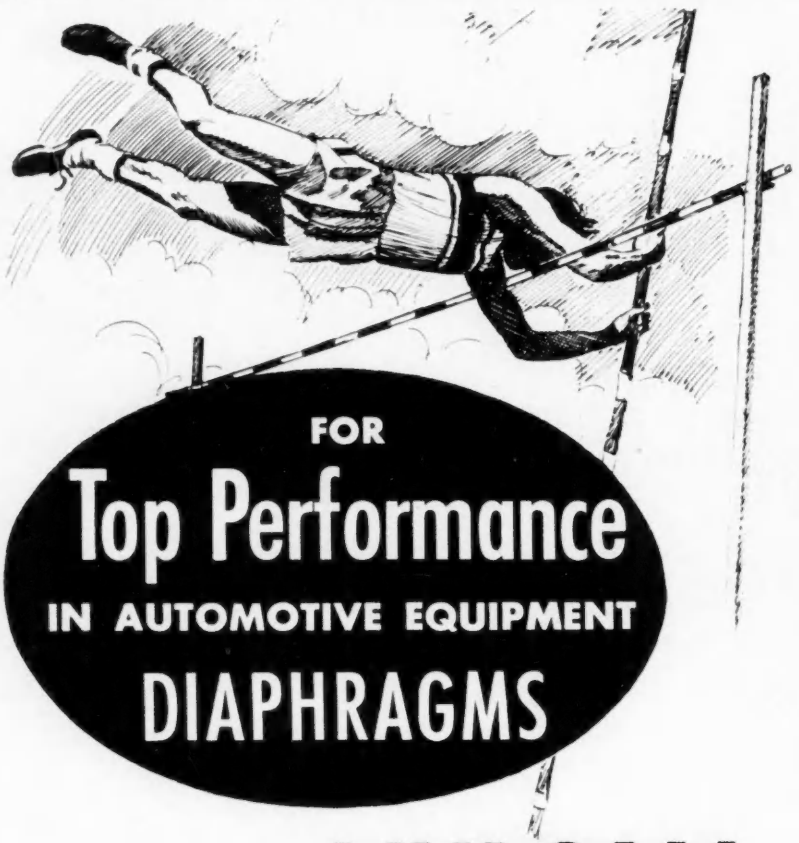
4. Full throttle converter multiplication is 2.2 to 1 (at standstill). The planetary reduction in both low range and reverse is 1.82 to 1, giving a total full throttle reduction of about 4.0 to 1 in these ranges;

5. Axle ratio used is 3.55 to 1, and a 235-cu-in. engine is used in all Powerglide-equipped models;

6. A supplementary fluid coupling is built into the torus section of the converter to assist in engine braking and deceleration;

7. A positive parking lock is provided, and a secondary drive-shaft-driven oil pump permits push starting of the car.

Harry Stanton, automotive editor of the Boston Globe, gave another of his informative "Automotive News" talks. More than 100 members and guests were present at the dinner, and others joined the group for the speakers' program, to make this one of the Section's largest meetings.



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Names Factors in Brake Performance

• Cincinnati Section
Walter Walkenhorst, Jr., Field Editor

March 26—Safe and adequate brake performance, requires definite limitations for each of the three basic elements involved: the vehicle, the driver, and the road.

Paul J. Reese, automotive application engineer of Wagner Electric Corp., told 60 members and guests of this Section that brakes must have adequate capacity for the vehicle's weight and speed; effort required to operate brakes must be kept as low as possible; and the character of the surface of the road and the tires must be considered fundamental factors that dictate design possibilities and limit braking performance.

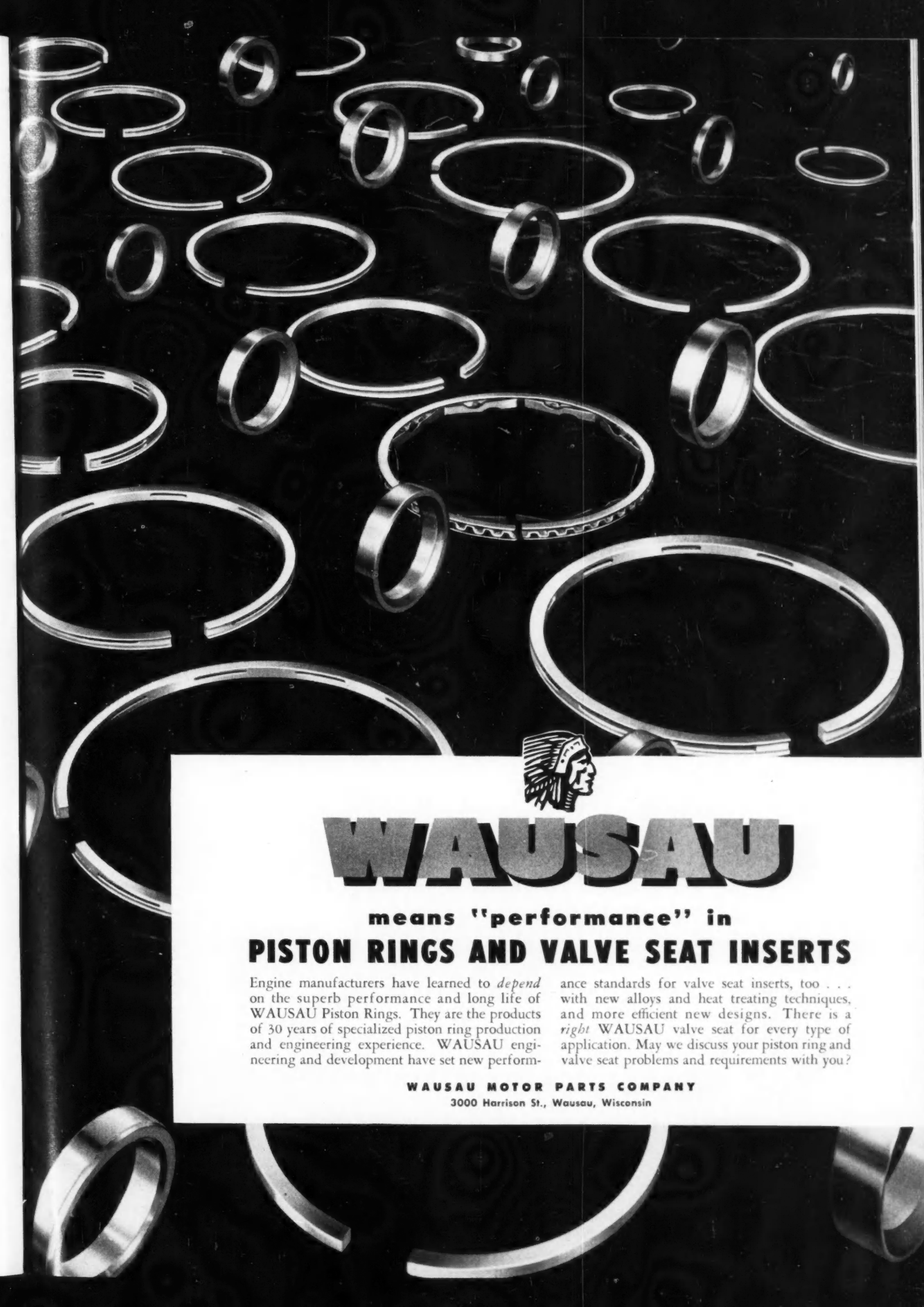
The formal discussion was followed by the usual social hour, when many other automotive brake operation questions were answered.

Cites Advantages Of Valve Rotation

• Mid-Continent Section
D. W. Frison, Field Editor

March 23—"Excessive valve temperature keynotes the valve failure problem", **A. L. Pomeroy** informed 75 section members and guests at Oklahoma City. Pomeroy, who is director of development for Thompson Products, Inc., Cleveland, went on: "Inadequate design and operational deficiencies lead to valve deterioration through their influence on valve temperature. In many cases, improved design or closely controlled operation can be of great help.

"While rotation is of value primarily in coping with deposition", he continued, "it does alleviate the temperature problem. Tests have shown that



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valve rotation is applicable to all types of engines and fleets and can result in valve life improvements of two to five times. The application of the valve rotator represents," he concluded, "possibly the greatest advance in valve engineering since sodium cooling and hard facing."

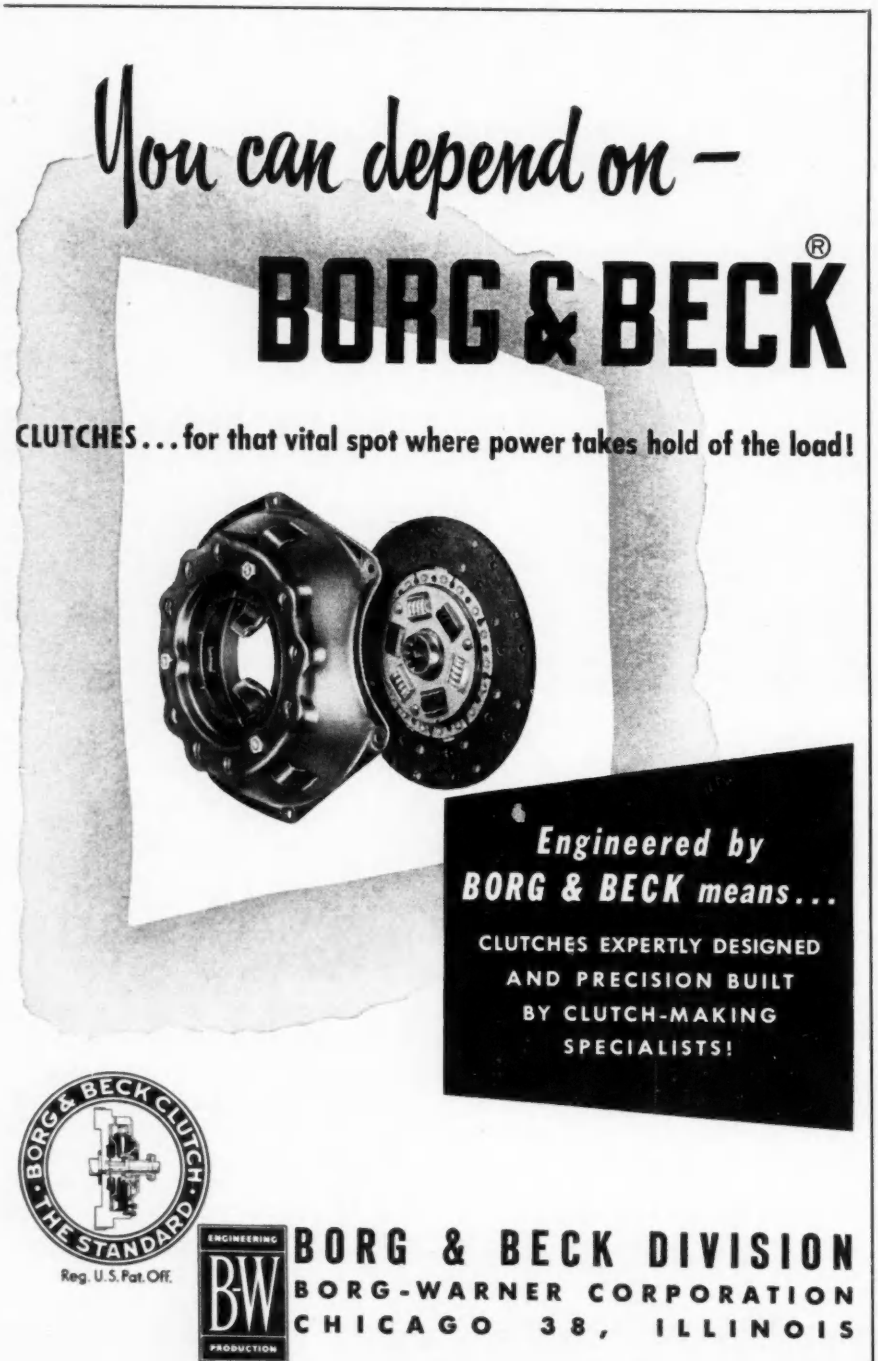
Valve rotators are classified as "Release Type" and "Positive Type", the latter being an improvement since it results in controlled, positive rotation and does not require close tolerances and thus reduces wear of component parts.

Valve steel facing materials, sodium-cooled valves, valve face angle and improved lubricating oils have contributed to increased valve life. In many instances valve life improvements obtained through rotation are additive to those incurred through design or operational changes.

Rotation is not necessarily confined to exhaust valves. In equipment where intake valves are marginal because of sticking or face deposition, the Roto Cap has been found to be equally effective. In some cases, however, this application may necessitate a change in the intake valve material to avoid valve face grooving if steel is too soft.

Valve guide wear is reduced by rotation and undue tip wear is prevented, the latter of importance since proper lash adjustment is not upset.

In Pomeroy's words, "valve rotators have made the statement, 'valves that turn are tough to burn' almost axiomatic."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Covers Old and New Ignition Systems

• Philadelphia Section
M. A. Hutelmyer, Field Editor

March 14—This meeting, arranged by J. J. Mikita, of E. I. duPont de Nemours & Co., Inc., was devoted to a discussion of present automotive ignition systems, suggested methods of improvement, and future systems. Joseph Johnson, of Pratt & Whitney, the technical chairman, pointed out that the present system is highly efficient and quoted two "small" items to prove his point.

1. An ordinary set of breaker points on an 8-cyl car in 800 hr or 16,000 miles of operation will break 566 million times.

2. In the early days of the industry, the mica spark plug had a life expectancy of about 25 hr, as compared to the several hundred hours of today's plugs.

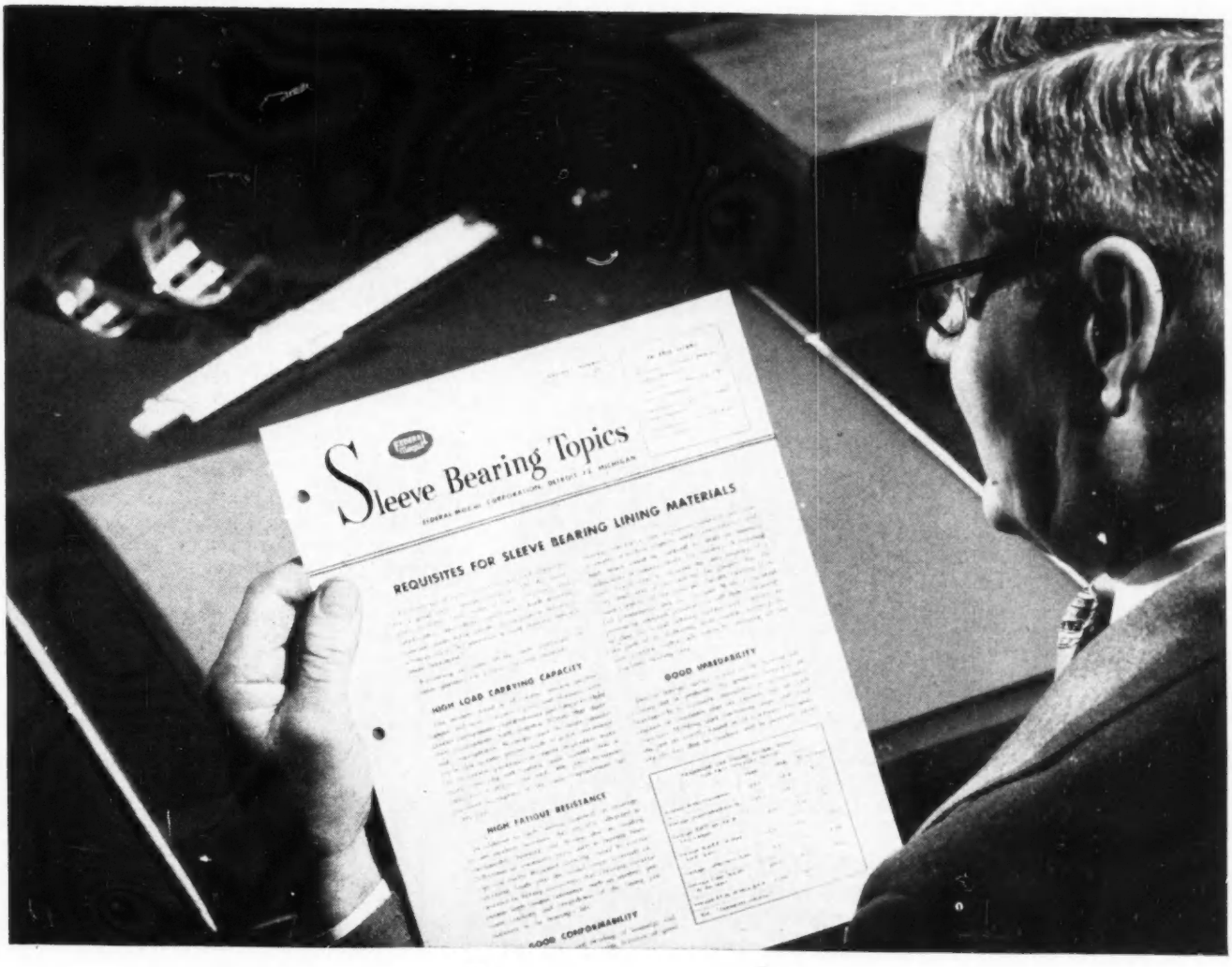
The principal speaker, **H. L. Hartzell**, assistant chief engineer of GMC's Delco-Remy Division, added emphasis to Johnson's opening remarks by pointing out that today's low-cost automotive ignition system is expected to deliver from 5000 to 20,000 volts to the plugs at least 100,000,000 times without attention, and do it even when wheels are showering it with mud, slush and salty water.

Hartzell then pointed out that two methods of storing energy are: (a) a magnetic field, and (b) a condenser.

The condenser storage method is not new, since it has been used on Waukesha CFR engines since 1932. The main difference in recently proposed systems is in new designs for power supply, condenser, size, switch and transformers.

The power supply systems must be able to supply in the range of 20 to 80 millejoules per pulse, and from 1000 to 3500 volts. Three methods of obtaining this voltage are being used: The synchronized and timed pulse system; the synchronized and rectified pulse system, and the constant frequency and rectified pulse system.

The first system is essentially the



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same as the present coil and breaker system, except that the turn ratio of the windings is much lower and requires the use of a spark gap which will break down consistently at the desired voltage. The ignition timing is controlled by the timing of the pulse. This system has the advantage of lower cost, but the disadvantage of limited energy output. A 12-volt or higher voltage system would be required.

The second system uses a synchronized but untimed alternator power supply. The output of a small alternator is rectified by a full-wave selenium rectifier. The rectifier is essential, as it prevents the condenser from discharging back through the alternator and also rectifies the alternate polarity pulses of the alternator.

The advantages of this method are that the output is only limited by the size of the component parts. The disadvantages are cost and size.

The third system—the constant frequency and rectified power supply—is of the same type as is used to supply plate voltage in auto radios, except that the output voltage must be 4 to 10 times higher. A rectifier similar to that described in the second system can be used. This system is cheaper than the second system, but not as reliable, and does not have as much output.

Hartzell detailed a number of complete system based on the above, then described a system Delco-Remy is investigating that features the use of electronic tubes in a high-frequency system and shows promise of being very succesful.

In regard to future systems, Hartzell predicted that none of the systems he outlined would be in general use in the next 15 years. Since the present system is being stretched to its limit for an 8 to 1 compression ratio engine, and is definitely inadequate for a 12 to 1 ratio, probably within the next few years many passenger cars will change to a 12-volt system, which will permit the use of the simple, single-coil, single-breaker system, and obtain satisfactory performance for the 12-1 engine.

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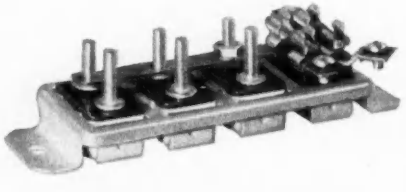

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LP Gas Symposium Presented at Milwaukee

• Milwaukee Section

E. L. Conn, Field Editor

March 2—A very timely symposium was conducted to discuss the use of Liquefied Petroleum-Gas as a direct motor fuel. The use of LP Gas is not restricted to tractors, but has found application in off-the-highway uses as well as in trucks and buses. Panel members of the symposium were **F. E. Selim**, Phillips Petroleum Co.; **A. J. St. George**, Ensign Carburetor Co.; and **Marvin J. Samuelson**, Minneapolis-Moline Co.

The three members of the panel presented their views on the subject by reviewing the papers which they had presented at the 1951 SAE Annual Meeting, and since the substance of these papers will be published in the Journal at some later date, the following is only the discussion of questions and answers.

In answer to the question as to what price differential between gasoline and LP Gas makes LP Gas profitable, it was pointed out that this depends upon operation and quantity of fuel used, because storage handling and conversion are factors. As a rule of thumb, the value of 3 to 5¢ per gal differential could be used.

On the subject of starting, the panel was asked why starting was difficult under cold conditions, even though propane is gaseous at zero degrees temperature. Answers to this question

pointed out that the cylinder may not get a concentration of charge, and, as a consequence, firing may occur, but not enough to run the engine. Also, because of the lack of dilution of the oil, no oil viscosity reduction occurs; thus the drag due to oil viscosity is greater. Another factor is the metering of the fuel. It was stressed, however, that proper know-how enables starting at 30-to-40 F.

As reasons why the use of LP Gas has not been applied to passenger cars, the following remarks were made by the panel: The cost of conversion is too much for the average motorist; there is no place to put the pressure tank; it is questionable whether car owners would provide proper maintenance and inspection; last, at the present time, LP Gas is not generally available.

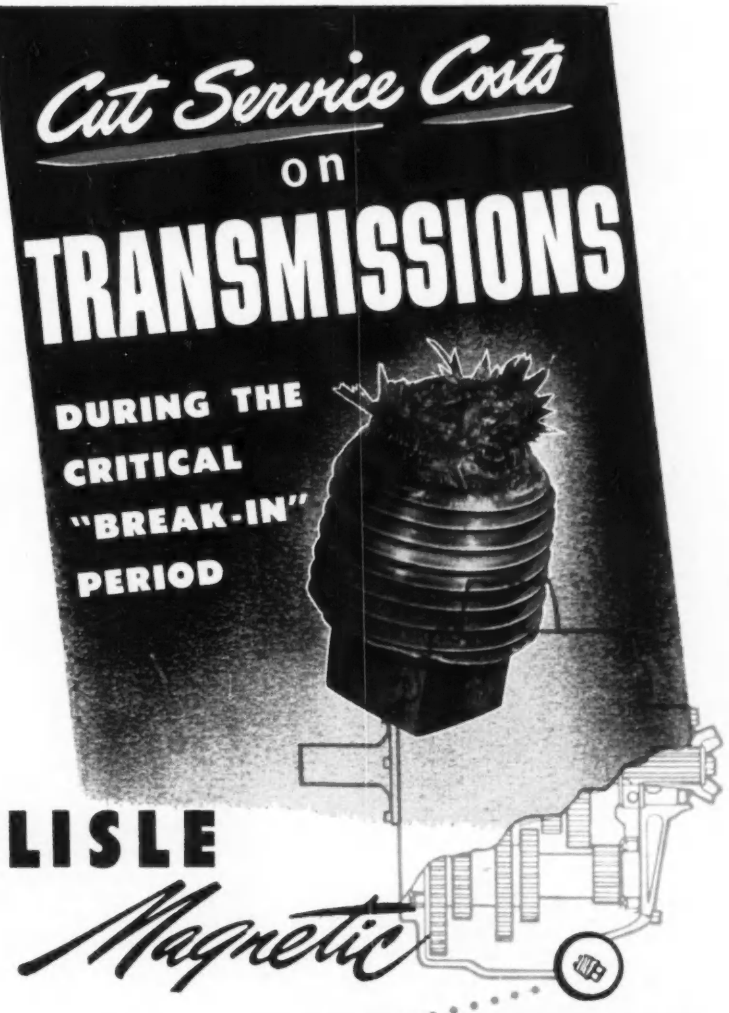
Predicts Bright Future For Ramjet Helicopter

• San Diego Section
Charles F. Derbyshire, Field Editor

March 29—The Helicopter Age is just around the corner, according to **C. Langhorne Washburn,** assistant to the president, Hiller Helicopter Corp. Early difficulties encountered in design of ramjet propulsion units are being overcome, with an economically practical specific fuel consumption in the foreseeable future. Ramjet power units, located at rotor blade tips, eliminate all the complexity and resultant high cost inherent in piston engine drive mechanisms, either coaxial or tail rotor stabilizing type. Seven parts in the rotor assembly replace over 100 in the piston-engine-driven type. Noise level is not objectionable, conversation being easily possible in the enclosed cabin. Present selling price of the ramjet helicopter is much lower than for its piston engine counterpart, with still greater economies possible in quantity production. Range and fuel economy remain to be improved but do not present insurmountable problems. When this is done, the day of the "helicopter on every garage" will be here.

Metropolitan Section Holds Largest Thursday Luncheon

The most successful noonday event in Metropolitan Section's history brought 92 people to Thursday lunch at the Hotel Commodore on March 22, and 35 more to the Chrysler Theatre across the street to hear **M. B. Rice,** regional service manager of Chrysler Corp., describe the new Chrysler Firepower engine. Rice talked for an hour about the 180-hp V-8 engine, and many



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members stayed for as long as an hour afterward to ask questions.

From a small beginning early in 1949, the luncheons have grown in attendance and importance until now the semi-monthly functions draw an average attendance of over 30 and regularly feature talks on up-to-the-minute subjects certain to interest a majority of the membership.

The last luncheon for this year, scheduled for May 10, will feature luncheon at the Commodore followed by a specially-scheduled tour of the Chrysler engineering exhibit in the Chrysler Building.

Hamilton S. Sherwood of McCann-Erickson originated and carries on the idea as chairman of the Met Section Luncheon Committee, with the able assistance of R. M. Cherryholmes of Shell Oil Co.

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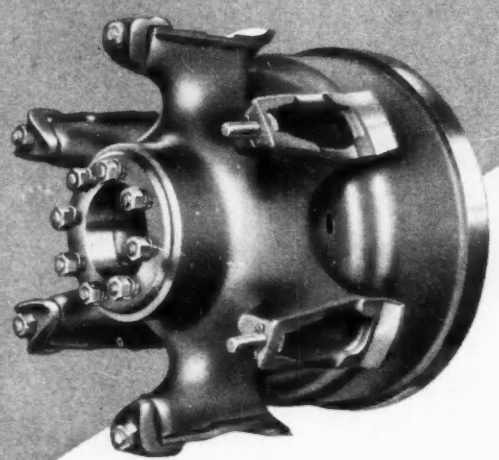

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Airline Safety

Continued from Page 71

based on data which the industry itself can obtain. If the achievement of safety were done for itself, not for competitive reasons, politics might play less of a role as an undercurrent in safety activity. Safety is the resultant of all the policies of which it is composed. We should strengthen those vectors that point toward the place in society that flying should earn—the safest form of transportation.

(Paper "Observations on Flight Safety" was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Magnesium and Titanium Win Ordnance Favor

Based on paper by

COL. BENJAMIN S. MESICK

U. S. Ordnance Department

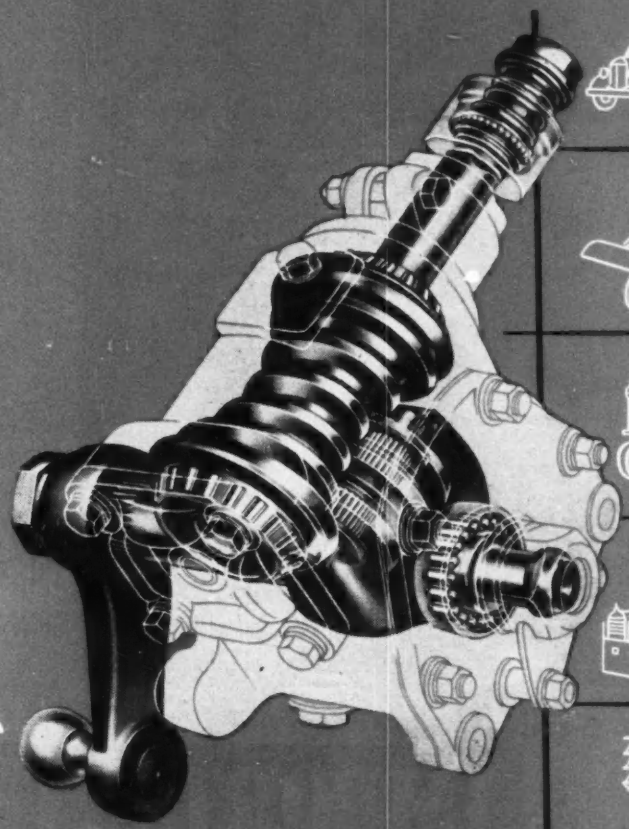
CONSTANT demand for better performance with weight reduction in all classes of Ordnance equipment has led us to consider all kinds of construction materials which provide a high strength-density ratio. Although much can be done with high strength steels, there are many applications where further savings cannot be made through reduction of section thickness and some material of lower density must be sought.

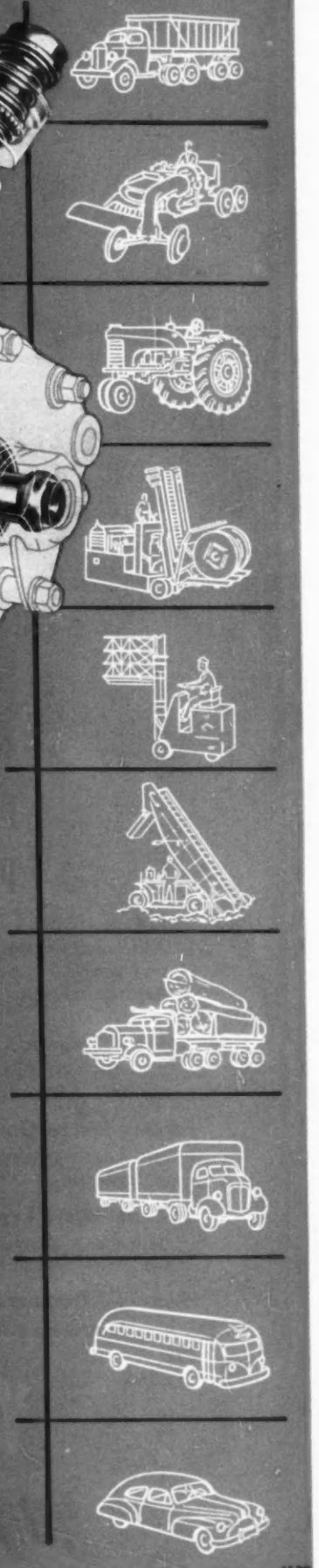
The natural limitation on the availability of aluminum forces us to turn to magnesium which can be produced in larger quantity. Several factors have retarded wide use of magnesium alloys in Ordnance design. Chief deterrents have been the lack of definite knowledge of the material's possibilities and limitations, and scant experience in fabrication, but poor resistance to abrasion, heat, and corrosion have been real obstacles.

However, the practically unlimited supply of raw material, particularly magnesium salts in sea water, and steady progress made in developing alloys with better physical properties. has led Ordnance to continue search for solutions to technical problems.

Research at the Frankford Arsenal to develop a protective surface treatment has had encouraging results. It

Gemmer Easy Steering Lowers Costs





by Cutting Maintenance . . . and Speeding Schedules

Easy maneuverability of Gemmer steered vehicles helps to make faster schedules through traffic, in and out of parking places, docks and narrow entries. The lessened steering load substantially reduces driver fatigue. No letdown the latter part of the day. Increased mileage per vehicle makes for important reduction in operating as well as capital costs.

Gemmer Easy Steering cuts maintenance. Having little or none of its own, it contributes to reduction of over-all vehicle maintenance. Easy maneuverability plus alert, untired drivers help hold down vehicle damage costs.

Gemmer Easy Steering is always responsive, firm, with no rubbery feeling or wander. Rolling gear tooth sector, plenty of antifriction bearings, almost eliminate friction. Strength is abundant and there is plenty of power for parking.

With reasonable care, a Gemmer Steering Gear will last the life of the vehicle.

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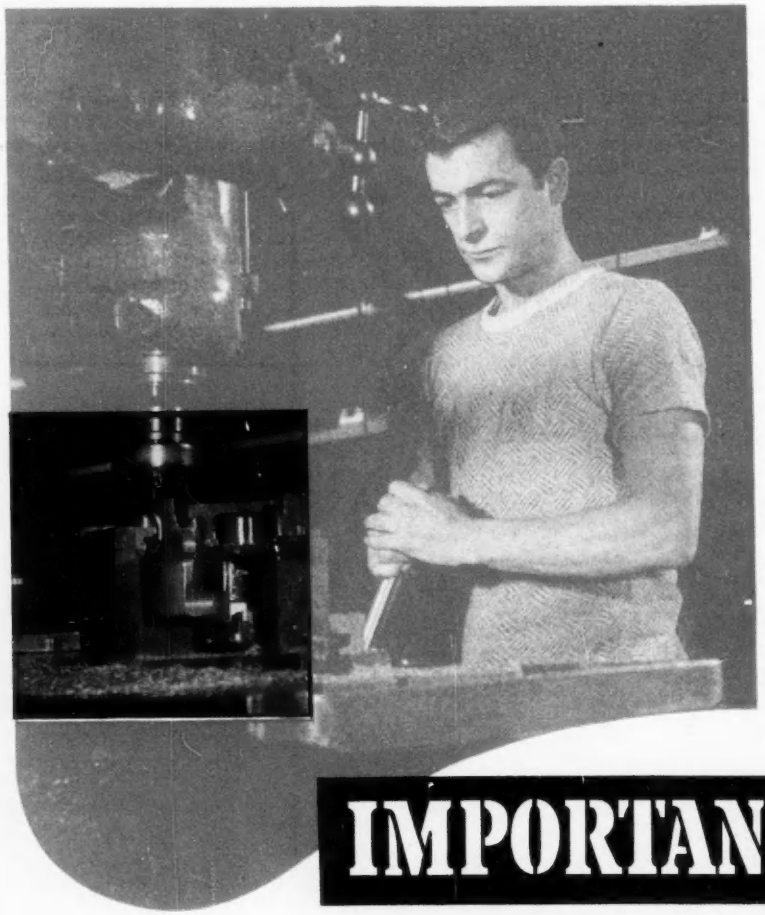
Gemmer Has Made Motor Vehicle Steering Gears for 43 Years

4123



IMPORTANT

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For more than 35 years The Pierce Governor Company, Inc. of Anderson, Indiana, has excelled in the design, engineering, and production of important parts for the Automotive and Aircraft industries. Today's production features:

Sisson Automatic Chokes

Complete line of precision engineered chokes for the automotive industry—original equipment and replacement parts

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Design and manufacture of precision hydraulic and mechanical fuel control systems for leading aircraft engines

Hydraulic Transmission Controls

Manufacture of sensing mechanisms for hydraulic transmissions

Let Pierce's precision engineered products and manufacturing facilities solve *your problem!* Write . . .

The Pierce Governor Co., Inc.
Anderson, Indiana

PIERCE

can be said at this time that we are nearing completion of development of a series of treatments which provide corrosion protection far beyond anything now in use commercially. These treatments also give excellent resistance to abrasion and heat. We expect this to open the way to wider use of magnesium alloys in both Ordnance and industry.

Although titanium and titanium alloys are not used in any Ordnance item currently scheduled for production, the availability of titanium ore, the exceptional strength of the alloys at normal temperatures, and unmatched corrosion resistance, make it appear certain that these alloys will be used in many Ordnance items where it is important to reduce weight and improve performance.

It is conceivable that titanium alloys can be substituted thickness for thickness for steel armor to effect a weight reduction of about 40%. Similar weight savings in certain structural components of military vehicles are also anticipated. (Paper "Materials of Military Motorized Equipment," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers).

Hard-Facing Lengthens Life of Rotating Valves

Based on paper by

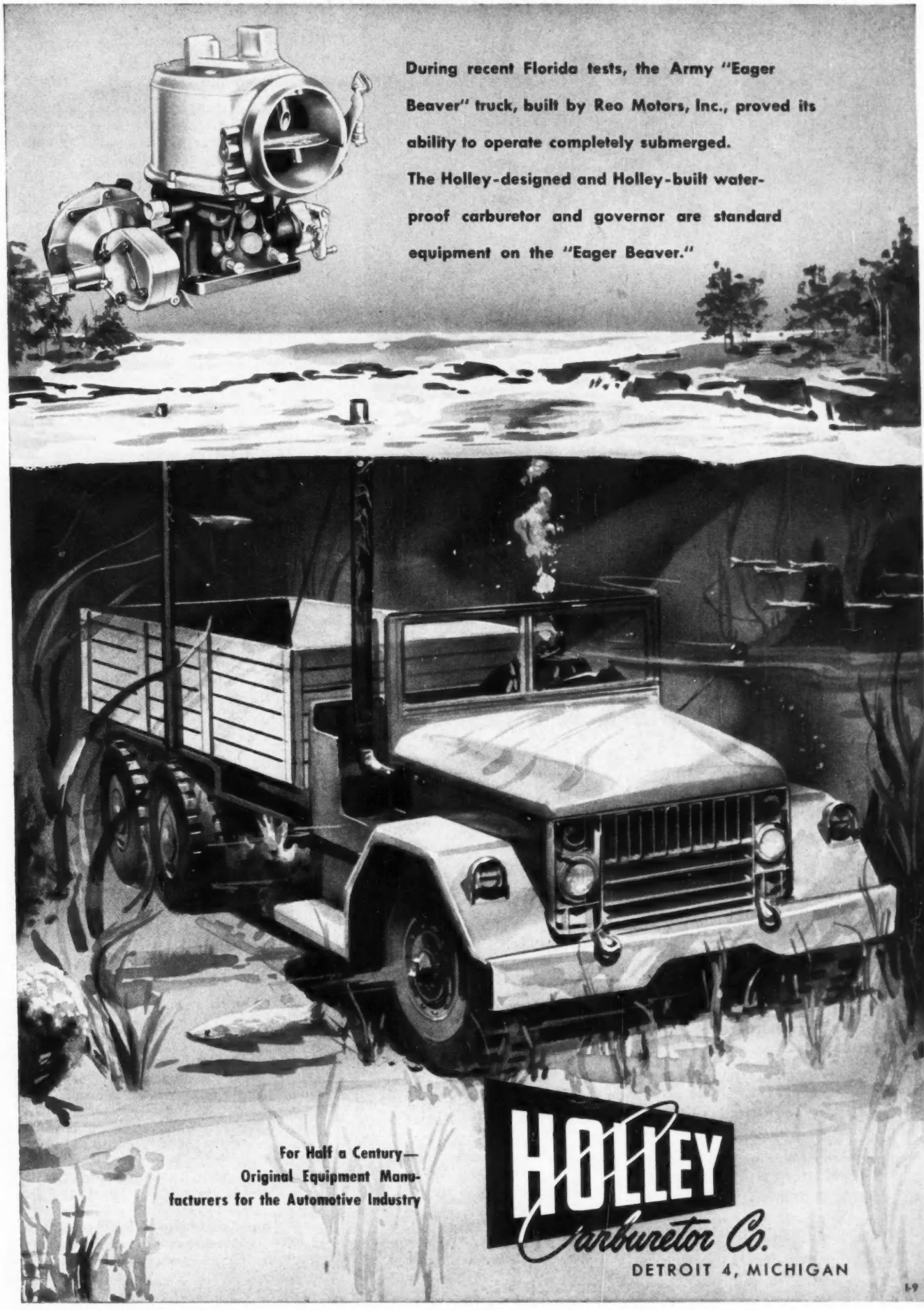
HERBERT C. SUMNER

Ethyl Corp.

IN heavy duty service hard-facing is generally necessary in conjunction with rotation to take full advantage of benefits available from rotation. Although rotators reduce high temperature leakage past the valve face by keeping deposits from accumulating on valve stems and faces, some intermittent leakage is bound to occur from valve seat distortion or pieces of deposit catching between the valve seat and face.

If the engine is working hard and exhausting very high temperature gases when the leakage occurs, the valve may burn before the seat is restored, unless it is faced with a highly corrosion resistant material.

If, on the other hand, the engine is not in heavy-duty service and intermittent leakage occurs, the temperature and quantity of the exhaust gases may not be enough to raise any portion of the valve face to particularly high values. In this case the presently


During recent Florida tests, the Army "Eager Beaver" truck, built by Reo Motors, Inc., proved its ability to operate completely submerged.
The Holley-designed and Holley-built water-proof carburetor and governor are standard equipment on the "Eager Beaver."
For Half a Century—
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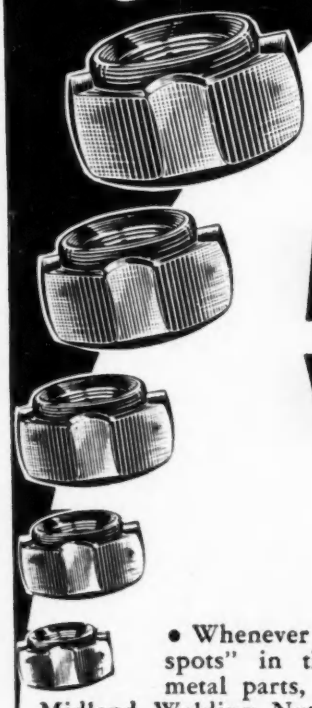
DETROIT 4, MICHIGAN

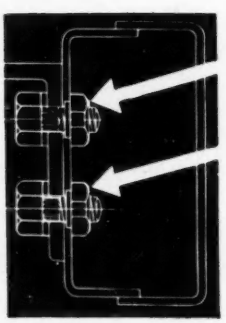
SAVE TIME in the Assembly of Metal Parts



Simplify Attachment with MIDLAND WELDING NUTS

• Whenever there are "blind spots" in the assembly of metal parts, as shown here, Midland Welding Nuts are especially useful. Bolts can be turned into Midland Nuts, without needing any device to hold the nuts from turning. Their use helps to speed production.

Investigate! Midland Welding Nuts may be the answer to some of your assembly problems.



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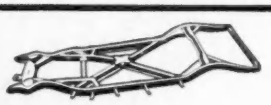

Air and Vacuum POWER BRAKES

Air and Electro-Pneumatic DOOR CONTROLS

available valve materials may withstand burning without the addition of a hard-facing material.

Field experience thus far has shown that neither farm tractor engines nor city bus engines ordinarily require hard-facing with rotation. (Paper "Valve Rotation" was presented at SAE Cincinnati Section, Nov. 20, 1950. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Method for Analyzing Gas Turbine Cycles

Based on paper by

ARTHUR S. LEONARD

University of California

THIS paper presents the calculation methods, both numerical and graphical, to reach solutions of the irreversible adiabatic polytropic processes of constant polytropic efficiency with a perfect but non-ideal gas. It affords a means for analysis of gas turbine cycles in general, and for the internal combustion cycles in particular. (Paper "The Irreversible Adiabatic Polytropic Process with Variable Specific Heat and Its Application to Gas Turbine Cycle Analyses," was presented at SAE National Meeting, Detroit, Jan. 10, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Maintenance Demands Better Inspection

Based on paper by

DAVID H. MIKKELSON

Schuman Carriage Co

WE must rely more on inspections and we must develop inspection technique and the inspector himself to a much higher degree of efficiency. Instead of overhauling at a set time of mileage we should do them only when vehicle condition requires such attention. The basic problem is to find this out without spending a great deal of money.

We must develop ways and means to locate troubles just prior to failure. This means we must have better men doing our inspections and they must be given more and better testing equip-

ment. The industry needs better instruments and it must have them if costs are to be cut.

Sound preventive maintenance programs can be set up and good inspection forms printed, but the key is the inspector himself. An inspection system is only as good as the individuals performing it. The men who are of primary interest here are the mechanics who perform inspections. They must be handpicked and given special training. The most important attributes for a good inspector are: dependability, mental alertness, and general mechanical knowledge and ability. The inspector performing major inspections should receive as much pay as any other top-grade mechanic. (Paper "Maintenance Inspections and the Inspector" was presented at SAE Hawaiian Section, October, 1950. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Tests Yield Facts On Hydraulic Damping

Based on paper by

J. E. CAMPBELL

North American Aviation, Inc.

(This paper will be published in full in SAE Quarterly Transactions.)

DEVELOPMENT of the high speed airplane has brought the airplane designer numerous new problems. One is how to design boost systems to provide the pilot sufficient power to operate the control surfaces at high speeds. Such design requires a knowledge of the damping characteristics of hydraulic system components for performance and stability analyses of the boost system.

Theoretical analysis and experimental work on a special test system were combined in the determination of hydraulic damping or resistance factors for various hydraulic system components such as straight tubes, bends, fittings, and flexible hoses.

Values of resistance for the different components studied were found to be essentialy independent of flow rate over the test ranges and can, therefore, be used directly in linear differential equation analyses.

Straight tube resistance per unit length was found to be inversely proportional to the fourth power of the tube diameter and approximately proportional to the square root of fluid dynamic viscosity.

The resistances per unit length of tubing bends and of flexible hoses are much greater than those for straight tubes. For example: the resistances per unit length of a typical 90 deg bend and a typical flex hose are respectively about 40 and 20 times that of the corresponding size of straight tubing. The average resistance to 90 deg flow in flared tubing fittings is approximately equal to 50 in. of straight tubing. (Paper "An Investigation of Hydraulic Damping" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Approved and Proposed Aero Material Specs

TWO new and 21 revised Aeronautical Material Specifications were approved recently by the SAE Technical Board. Nine proposed revised specifications are currently being circulated to industry for review and comment.

a. New AMS approved:

- AMS 7440, BALL, STEEL—Hardened
- AMS 7445, BALL, CORROSION RESISTANT STEEL, 17Chromium-Hardened

Continued

CONTROL POWER BETTER

ROCKFORD CLUTCH DIVISION
BORG-WARNER
316 Catherine Street, Rockford, Illinois

ROCKFORD CLUTCHES

UNITED OIL BATH AIR CLEANERS
PROTECTION STANDARD FOR DIRT-MOVING MACHINES

Wheel loaders . . . tractors . . . graders . . . self-propelled scrapers . . . dump trucks . . . whatever the type of earth-moving equipment, United Specialties Company provides an oil bath air cleaner to fit the need. With over 99 percent dirt-trapping efficiency, the scientifically designed United Cleaner permits only abrasive-free air to enter the engine — even under worst dust-saturated conditions.

Proved and specified for the toughest jobs, United Oil Bath Air Cleaners protect internal combustion engines in every field of use. We invite your inquiry.

Tractomotive Corporation specifies United Air Cleaner for its new Model TL-10 wheel loader. Designed with hydraulic torque converter drive, this new Tractomotive TractoLoader embodies the most advanced features in front-end loader construction. It is equipped with United Oil Bath Air Cleaner illustrated.

Trucks, cars, tractors, portable and stationary industrial engines by the millions have benefited from United Air Cleaner protection for almost 30 years. With over 260 models available, there is a United Oil Bath Air Cleaner for every type of internal combustion engine.

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★ AIR CLEANERS ★ METAL STAMPINGS ★ DOVETAILS
★ IGNITION AND TURN SIGNAL SWITCHES ★ ROLLED SHAPES

Approved and Proposed Aero Material Specs

Continued

b. Revised AMS approved:

- AMS 3214D, SYNTHETIC RUBBER, Aromatic Fuel Resistant (35-45)
- AMS 3228C, SYNTHETIC RUBBER, Hot Oil and Coolant Resistant (65-75)
- AMS 3229C, SYNTHETIC RUBBER, Hot Oil Resistant, Low Swell (75-85)
- AMS, 3240A, SYNTHETIC RUBBER, Weather Resistant, Chloroprene Type (35-45)
- AMS 3241A, SYNTHETIC RUBBER, Weather Resistant, Chloroprene Type (55-65)
- AMS 4611B, BRASS, NAVAL, 60.5Cu-0.8Sn-38.7Zn, Half Hard
- AMS 4614D, BRASS FORGINGS, FREE CUTTING, 60Cu-38Zn-2Pb
- AMS 4615B, SILICON BRONZE, 95.5 Cu-3.2Si, Hard
- AMS 4619B, MANGANESE, BRONZE FORGINGS, 58Cu-39.7Zn-1.1Fe-1.0Al 0.2Mn
- AMS 4631B, ALUMINUM BRONZE, 90.9Cu-7.2Al-1.9Si
- AMS,4632B, ALUMINUM BRONZE, 90Cu-8.5Al, Hard
- AMS 4635B, ALUMINUM BRONZE, 87Cu-10Al-3Fe
- AMS 4640B, ALUMINUM BRONZE, 81.5Cu-10.3Al-5.0Ni-2.8Fe
- AMS 4674A, NICKEL-COPPER ALLOY, CORROSION RESISTANT, 67 Ni-30Cu Free Machining
- AMS 5120C, STEEL STRIP, 0.64-0.76C (SAE 1070)
- AMS 5121B, STEEL STRIP, 0.89-1.04C (SAE 1095)
- AMS 5335A, STEEL CASTINGS, SAND, 0.5Cr-0.55Ni-0.2Mo
- AMS 6270F, STEEL 0.55Ni-0.5Cr-0.2 Mo (0.11-0.17C) (SAE 8615)
- AMS 6272D, STEEL, 0.55Ni-0.5Cr-0.2 Mo (0.15-0.20C3 (SAE 8617)
- AMS 6274F, STEEL, 0.55Ni-0.5Cr-0.2 Mo (0.18-0.23C) (SAE 8620)
- AMS 6475A, STEEL, NITRIDING, 3.5Ni-1.2Cr-.25Mo-1.25Al (0.21-0.26C)

c. Proposed revised AMS:

- AMS 2263A, TOLERANCES, Nickel and Nickel-Bas Alloy Tubing.
- AMS 3675A, INSULATION, SOUND AND THERMAL—Resin-bonded Glass Fiber, Fine Filament
- AMS 3676A, INSULATION, SOUND AND THERMAL—Resin-bonded Glass Fiber, Medium Filament
- AMS 4000B, ALUMINUM SHEET AND STRIP, ANNEALED
- AMS 4001B, ALUMINUM SHEET AND STRIP, (2S-O)
- AMS 4003B, ALUMINUM SHEET AND STRIP, (2S-H-14)
- AMS 4006B, ALUMINUM ALLOY SHEET AND STRIP, 1.25Mn (3S-O)
- AMS 4008B, ALUMINUM ALLOY SHEET AND STRIP, 1.25Mn (3S-H14)
- AMS 5382B, ALLOY CASTINGS, PRECISION INVESTMENT, CORROSION AND HEAT RESISTANT, Cobalt Base -25.5Cr 10.5Ni-7.5W.

Stabilization *instead of wall pressure...*

Illustrating the utilization of cast-iron bearing surfaces in a ring designed for replacement purposes.

of interest to engineers

Memo

From: **M. W. MARIEN, Chief Engineer**

SUBJECT: Consideration of the wear factor in Piston Ring Design

Curbing wear of cylinder walls has always been a major concern of piston ring designers. Here at Ramsey it is a factor that is never lost sight of by the Engineering Group.

One of the major principles employed by Ramsey in the interest of curbing cylinder-wall wear is the utilization of cast-iron contact surfaces. It is well-known to automotive engineers that the soft, graphitic content of cast-iron acts as a lubricant when it contacts a harder surface.

Ramsey Ring Design puts the cast-iron principle to work to insure proper preparation of the cylinder walls. Stabilization, rather than wall pressure to control oil and blow-by, is one of the reasons why it is possible for Ramsey to utilize this principle. Another is that, even though steel is used, it is employed as a secondary bearing surface, instead of a primary one.

We have found that the proper preparation of cylinder walls is one of the essentials to longer ring life and maximum curbing of the wear factor.

We welcome your inquiry regarding this and additional wear-curbing principles employed by the Ramsey Piston Ring Design, and how this design may be of use to you for original equipment, replacement or other purposes.

RAMSEY CORPORATION
General Offices, St. Louis, Missouri

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ROCHESTER GAUGES ARE BUILT TO

STAY ACCURATE

ON RUGGED SERVICE

When you design engines for heavy work, you make them tough enough to take plenty of hard knocks. Rochester instruments are built that way, too . . . for rugged service on your hard-working truck, tractor, auto, marine and industrial engines, both gas and diesel.

Rochester ammeters and temperature and pressure gauges are made of long-wearing metals to last as long as the engine itself. Their accurate, highly sensitive movements are protected with vibration and pulsation dampeners . . . and permanently sealed against water and dust. They always retain their original accuracy, too, even under high overloads.

Famous more than 35 years for long, dependable performance on heavy-duty service, Rochester instruments are specified as standard equipment by nearly all leading tractor and many other engine manufacturers. Bulletins on request. ROCHESTER MANUFACTURING CO., INC., 21 Rockwood St., Rochester 10, N. Y.

ROCHESTER DEPENDABLE ACCURACY GAUGES

ROCHESTER MANUFACTURING CO., INC.

DIAL THERMOMETERS GAUGES AMMETERS

Applications Received

The applications for membership received between March 10, 1951 and April 10, 1951 are listed below.

Baltimore Section

Harold A. Lafferty.

Canadian Section

Walter H. Cox, Avard A. Marr, William L. McGinnis.

Central Illinois Section

Edward J. Griffiths, Harold L. McCormack, DeWitt D. Wycoff.

Chicago Section

Richard A. Anderson, A. Wilbur Brandt, William G. Doke, George E. Frederick, Jr., Robert Jack Gyllenswan, John V. Jacobsen, Fay Eugene Kaiser, Jr., Hugo C. Lange, Truman C. Mason, Richard C. McRoberts, W. King Simpson, Renso John Vannelli, Frank R. Wemheuer, Fred William Wilken, Grady J. Zilligen.

Cincinnati Section

Robert E. Broxon, John F. Scanlon, Mercer Lane Threlkeld.

Cleveland Section

Richard Allchin, Everett L. Baugh, Edward Emmett Bock, W. C. Hohmann, Howard L. Hopkins, Walter Eugene Kappus, F. Ely Strohm.

Colorado Group

William Austin Nestlerode.

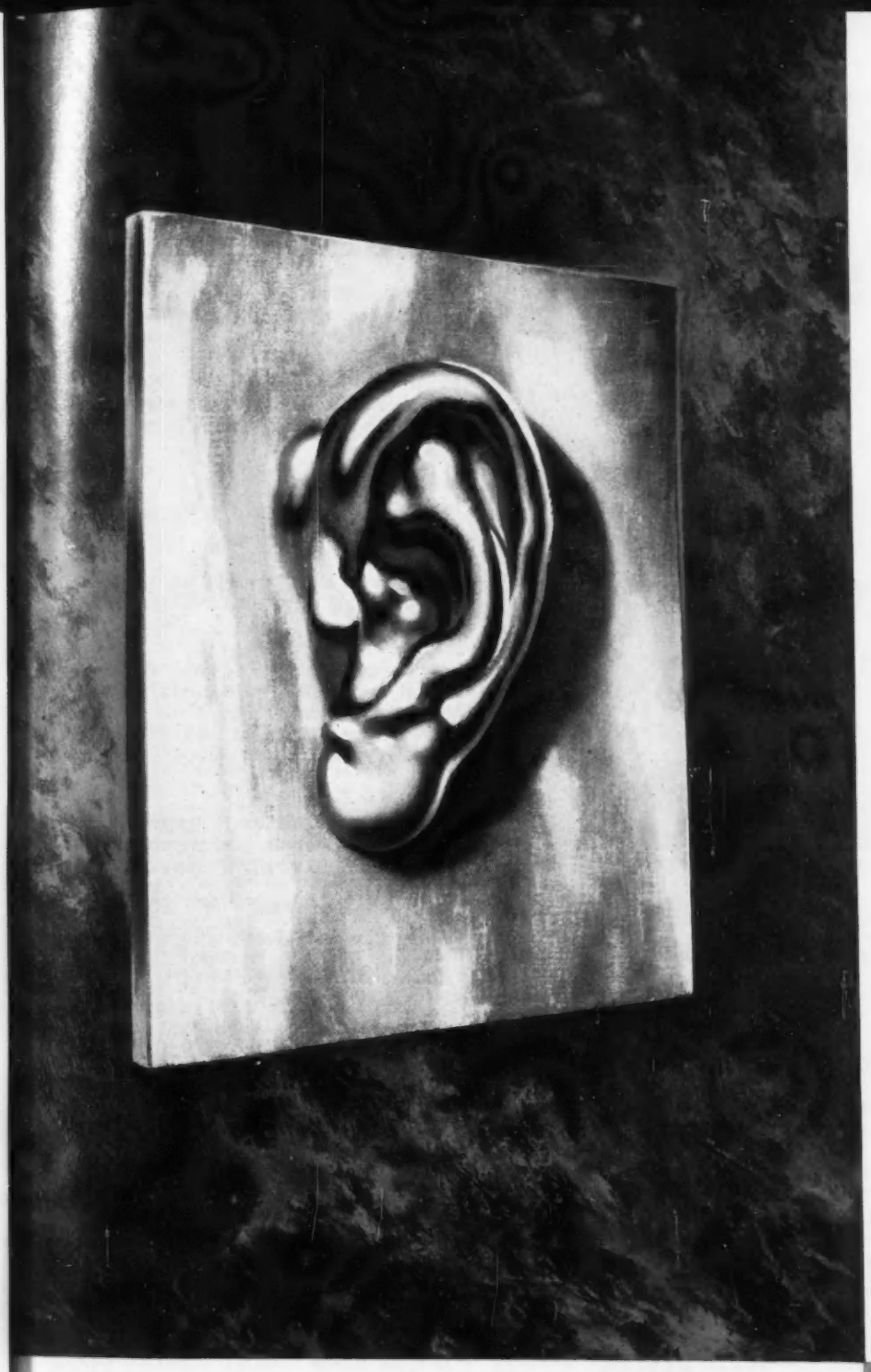
Dayton Section

Harold Walter Herring, Jack Klyce, Francis E. Stoner.

Detroit Section

Gene W. Anderson, Ernest 9. Bacsanyi, Orin U. Bales, Albert S. Beam, F. H. Bourke, Carl Robert Braun, Jr., David A. Brennan, Robert Loren Burns, William K. Burton, Robert H. Carter, William E. Day, Sr., John Dorian, Lawrence J. Gilsdorf, Mark D. Gross, Ronald B. Hay, Halvor W. Hem, Jr., Wilmer A. Hieronymus, R. H. Horner, William E. Judy, Wesley Kaupp, Mitchell C. Kazen, John A. Krolicki, William E. Legowsky, Kenneth V. Lundquist, Clayton C. Luther, Robert Martin Lynas, Currie N. MacKenzie, Thomas T. Mikaelian, Max R. Miller, James T. Moore, Thomas O. Muhn, Leonard A. Nejman, Robert H. Nihill, Robert S. Phillips, Edmund J. Popiel, John W. Powell, Ralph John Rasmussen, Jack Melvin Roberts, Robert Ryndress, Thomas Neil Shockey, Walter Sikora, Charles David Simmons, Walter H. Simpson, W. A. Smith, A. E. Stanyar, Robert Kepler Slaymaker, Richard H. Stout, John H. Tabb, F. M. Urban, Lee L. Wade, Jr., B. H. Weil, David Charles

Continued on Page 110



LISTEN for the deceitful
words that promise new
freedoms but promote slavery.

Freedom is never lost
by a single act. It is stolen
by innocent sounding words
that breed doubt, suspicion,
and dissatisfaction.

Communism thrives
on sugar-coated promises
with pink centers.

Our country will remain free,
only if we LISTEN for the lies,
the half-truths . . .
and expose them.

BOHN ALUMINUM & BRASS CORPORATION
GENERAL OFFICES: LAFAYETTE BLDG. • DETROIT 26, MICHIGAN

EXTRUSIONS • CASTINGS • FORGINGS • PISTONS • BEARINGS
INGOTS • AUTOMOTIVE REPLACEMENT PARTS • AIRCRAFT PARTS

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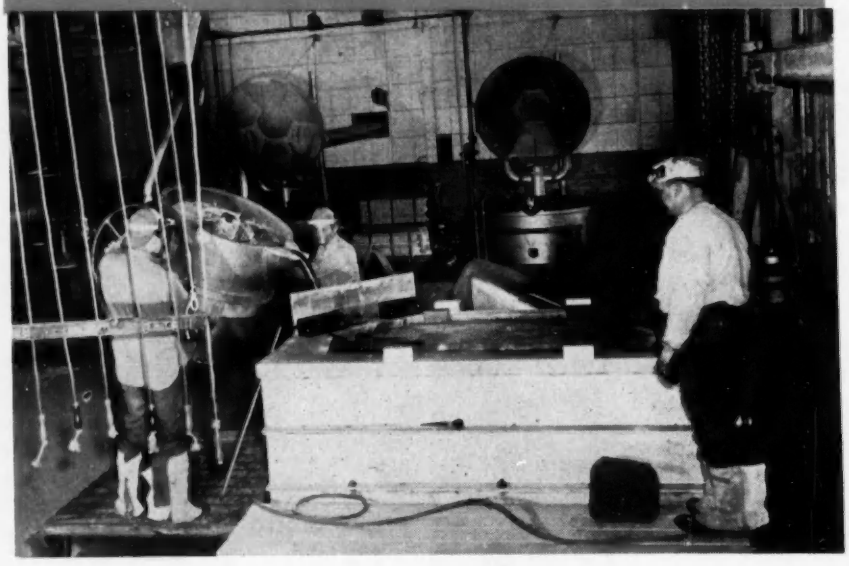
BOHN

NOW A DIE SHOP with EXTRA SERVICE



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1. **Allite** dies enable quick, accurate and economical production of experimental or short run parts.
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3. **Allite** dies enable ordering of supplementary production tooling sooner than normally possible: proven dies are on the job at an early date.

Allite dies may hold the solution to your experimental or production die problems. Why not write us today and let our engineers discuss them with you.

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RICHARD BROTHERS DIVISION
DEPARTMENT A-2
12643 BURT ROAD • DETROIT 23, MICH.

***ALLITE**
dies are precision cast for low cost tooling. The material used is any formula of zinc alloy (Kirksite, Di-Metal, etc.) which meets your requirements.

HARDENED AND PRECISION GROUND PARTS · STANDARD CAP SCREWS · SPECIAL COLD FORGED PARTS · SHEET METAL DIES FROM THE LARGEST TO THE SMALLEST · ALLITE ZINC ALLOY DIES · JIGS · FIXTURES · R-B INTERCHANGEABLE PUNCHES AND DIES

Applications Received

Continued

Weiss, Albert F. Welch, James E. Winterhalter, George H. Kohring.

Indiana Section

John Forrest Geneva, Walter H. Hocker, Jr., William M. Myers, Edward A. Poste, Milo M. Schalla, Harold W. Stoelting.

Kansas City Section

Leonard R. Buff, Stanley M. Lovell.

Mid-Michigan Section

John W. Burnside, Martin J. Caserio, Roy J. Griffin, Roger A. Huntington.

Metropolitan Section

Clements J. Boyers, John S. Davey, Paul deSamelson, Vincent J. Grande, James J. Irwin, David William Mansell, James B. Peeso, Jr., Stanley J. Solon, Robert M. Whelan.

Milwaukee Section

John P. Boynton, Raymond W. Fabere, Walter R. Laster, George G. McManis, William G. Pierce.

Mohawk-Hudson Group

G. Warren Hull.

Montreal Section

Arthur John Gittins, Jules George Grandon, George R. S. Henry.

Northwest Section

Judson L. Bruns, Jr., John Garfield, Jr., George H. Stephens.

Oregon Section

B. Nealley Wood.

Philadelphia Section

Thomas J. Bowes, George M. Bunn, Stanley A. Olsen, John J. Reitano.

Salt Lake Group

Richard D. Van Derck.

St. Louis Section

Robert G. McCullough.

Southern California Section

George N. Bennett, Arthur William Brooks, Galen Butterbaugh, M. K. Carter, Harold W. Ensign, Robert E. Roberts.

Southern New England Section

Ronald W. Campbell, Erling D. Sedergren, Walter Norman Stone.

Syracuse Section

Frank Germano Robert S. Seidel.

Texas Section

Allister L. Presnal.

Continued on Page 112

Condensed from 1950 Annual Report

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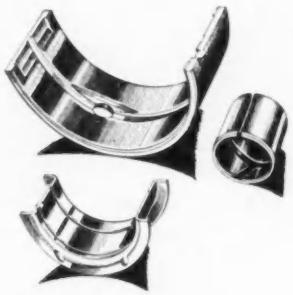
The Cleveland Graphite Bronze *Company*



Our business in 1950 was the largest for any peacetime year in our history, with revenues amounting to $42,506,042, comparing with $29,788,737 in 1949. Profit for the year was $3,914,228, or $5.75 a common share, as against $2,635,248, or $3.82 a share in 1949.

Production

With the motor car industry turning out 8 million cars and trucks, the automotive replacement market requiring parts in large volume, and the other industries we serve producing at expanded rates, the demand for our products was heavy through the year. We were limited by the amounts of materials we could procure, and despite the best efforts of our suppliers, it was impossible for us to deliver as large quantities as were desired by many customers.

An important forward step was taken in our production of Diesel engine bearings. Following a three-year period of research, we began in 1950 to produce large diameter, heavy-duty Diesel bearings by means of our "thinwall" process, which has proved so successful in producing bearings for automobile engines. On a complete set of bearings for a Diesel locomotive engine, 256 pounds of metal are saved and overhauls are greatly simplified. Many sets of these bearings are now making remarkable records in service, and we believe they will soon become the standard for the Diesel industry.

Our research program has developed several new products which are being held in abeyance at present, but which are ready for the market whenever sufficient materials and production facilities become available.

Employee Relations

During 1950 all of our labor negotiations were conducted without the loss of working time. At six of our plants basic agreements were amicably arrived at which should facilitate good relations and make for uninterrupted production during the busy years which lie ahead.

Among the benefits enjoyed by our employees were vacations and holiday pay costing $711,245, a Christmas gift costing $248,431 and company-paid Social Security contributions of $259,286. Employees also received $22,245 in awards for submitting 251 usable ideas handled through our Suggestions System.

Expansion Program

Our part in defense programs established to date, plus our estimated civilian business, is expected to increase our production by the latter part of 1951 to a rate perhaps 50 per cent above our present operations. To handle the expected volume, manufacturing facilities at least one-third greater than our present capacity, and perhaps considerably more, will be required. We therefore plan to establish five new branch plants, to be located in small communities for reasons of dispersion, security, and manpower supply.

To provide the necessary new money, we plan to obtain $5,000,000 by the sale of new preferred stock and $10,000,000 through a 20-year loan from an insurance company. Approximately $3,250,000 of this money is to be earmarked for buildings and approximately $1,750,000 for equipment. The remainder will be retained for greatly expanded working capital needs.

The $1,750,000 of equipment to be purchased is to be supplemented by about $5,500,000 of equipment provided by the government on a rental basis for producing aircraft and ordnance products.

Should future events call for further expansion beyond this program, additional financing would become necessary. Therefore, our stockholders are being asked to authorize the $5,000,000 of preferred stock now required, plus an additional $5,000,000 which could be issued later if needed. We are also arranging so that the $10,000,000 loan could be increased later by as much as $5,000,000 more.

Our company's part in the national defense effort will be an important one. We have already accepted large defense orders and are being asked to take on additional business in amounts which, even with our expansion program, will challenge our production ability to the utmost.

Ben F. Hopkins
Chairman

James L. Myers
President

Consolidated Financial Results

Year 1950

Sales and other revenues	$ 42,506,042
Wages, salaries, etc.	16,810,113
Materials, supplies, etc.	16,444,134
Depreciation	960,890
Real estate and other taxes	376,677
Federal and Canadian taxes on income	4,000,000
PROFIT FOR YEAR	3,914,228
Preferred dividends ($5 per share)	76,260
Common dividends ($2.60 per share)	1,733,448
Reinvestment of profit for year	2,104,520

Consolidated Financial Position

December 31, 1950

Current assets	15,306,887
Current liabilities	3,956,588
Property, plant and equipment, net	9,557,994
Other assets	418,884
NET ASSETS	21,327,177
5% Preferred stock, $100 par*	1,268,400
Common stock, $1 par	666,711
Capital received in excess of par value of common stock issued	520,315
Reinvestment of profit since organization	18,871,751
TOTAL CAPITAL	$ 21,327,177

**5% Preferred stock has been called for retirement on March 30, 1951.*

Since Organization in 1919

Total sales	$430,421,552
Total profit	36,026,801
Dividends paid on common stock	15,808,763

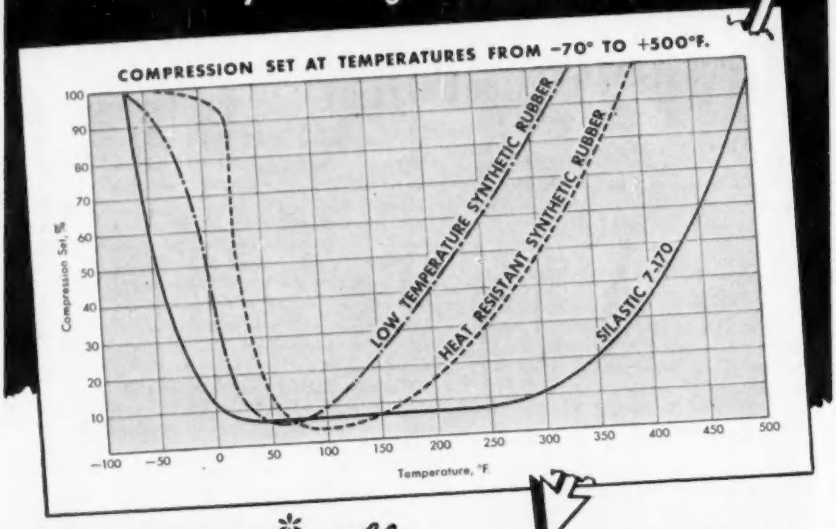
The Company began paying common dividends in September 1922, and has paid dividends, in various amounts, in every quarter of every year since then.

General Offices and Factory: 17000 St. Clair Avenue, Cleveland 10, Ohio

Branch and Subsidiary Plants at Cleveland, Milan, and Bridgeport, Ohio; Fort Wayne, Indiana, and St. Thomas, Ontario

A COPY OF THE 1950 ANNUAL REPORT WILL BE SENT UPON REQUEST

Where ordinary rubber gaskets fail . . .



SILASTIC* still stays Elastic!

AT EXTREME TEMPERATURES, Silastic has greater resistance to compression set—or to permanent deformation due to heat and pressure—than any other rubberlike material. Its elastic memory exceeds that of both the best low temperature and the best high temperature organic rubbers available. Silastic 7-170 forms a more resilient seal at −50°F. than a special low temperature organic rubber does at −7°F. At 450°F., Silastic has more resistance to permanent compression set than the most heat-stable organic rubbers have at 330°F.

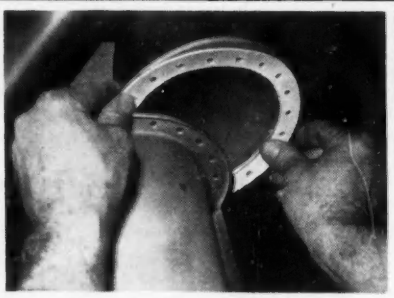
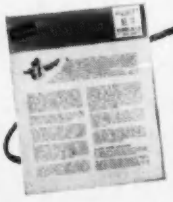


PHOTO COURTESY CONSOLIDATED VULTEE AIRCRAFT CORP.

In aircraft cabin heating and pressurizing systems, Silastic gaskets stay elastic under operating temperatures ranging from −70° to 400°F. Similarly, Silastic gaskets and O-rings withstand hot oils at about 450°F. in automotive, aircraft, diesel-electric engines.

Combine that kind of elastic memory with excellent resistance to aging, to oxidation and to attack by a variety of chemicals and hot oils, and you have Silastic—the most stable of all resilient gasketing materials. That's why design engineers and maintenance men specify Silastic, the Dow Corning Silicone rubber that pays for itself many times over in reduced maintenance costs and improved performance.



SEND TODAY!

For your copy of Silastic Facts No. 10 containing new data on the properties, performances and applications for all Silastic stocks.

*T. M. REG. U. S. PAT. OFF.

from +500°F. SILASTIC stays Elastic to −100°F.

DOW CORNING CORPORATION, DEPT. V-5, MIDLAND, MICH.
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Company_____
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City_____ Zone ____ State_____

Dow Corning
FIRST IN SILICONES

Atlanta • Chicago • Cleveland • Dallas • Los Angeles • New York • Washington, D. C.
In Canada: Fiberglas Canada Ltd., Toronto • In England: Albright and Wilson Ltd., London

Applications Received

Continued

Twin City Section

Richard H. Donaldson, Burnett V. Iverson.

Virginia Section

Marshall Brownlee Heizer, Jr., Robert Earl Williams.

Washington Section

C. A. Main.

Western Michigan Section

Joe L. Talbott.

Outside of Section Territory

John C. Drummond, Frank Fahland, Carl Glambeck, James Kennedy, Robert V. Mathers, Robert E. Munson, Robert R. Roth, Harold Silver, Delbert A. Smith, Charles Theodore Pobian.

Foreign

Paolo Beltramo Ceppi, Italy; Frank Ainslie Page, Australia; Claudio Reviglio, Italy.

New Members Qualified

These applicants qualified for admission to the Society between March 10, 1951 and April 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

Cecil R. Jones (A), Boyce Parkey (A).

Buffalo Section

Anthony J. Defino (M), Arlie A. O'kelly (M).

Canadian Section

Alfred Anthony Alessio (J), Albert W. Evans (A), Leslie Silburn Hazell (A), David Hamilton (A), Dale Herman Hill (J), William H. Martin (M), John Parkinson (M), Frederick W. D. Welham (A).

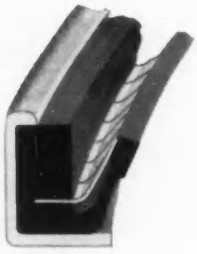
Central Illinois Section

Edwin R. Bredine (M), Ralph W. Dagenais (J), Donald E. DeCanniere (J), Arthur V. Houghton (J), George M. Johnson (M), Arnold Martin Kaiser (J), Robert T. Mees (M), Harold L. Ward (J).

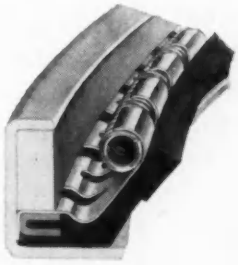
Continued on Page 114

Bearings are COSTLY

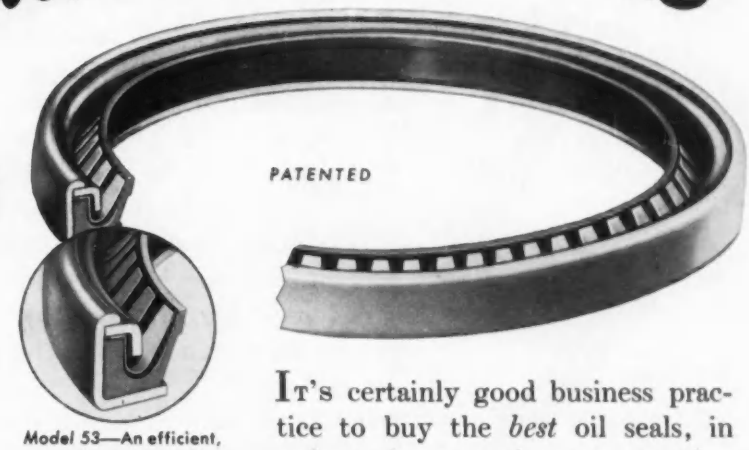
PROTECT Them with Garlock KLOZURES



Model 63—An efficient, general purpose seal for high speeds. For shafts 3" diameter and smaller.

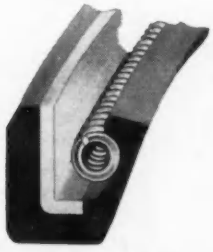


Model 64—A strong, effective seal for heavy duty on shafts of the largest diameter.



Model 53—An efficient, general purpose seal for high speeds. For shafts above 3" diameter.

Model 91A—A springless seal of small cross section, with the metal reinforcing member surrounded by rubber.



Model 91B—A spring-loaded seal of small cross section, with the metal reinforcing member surrounded by rubber.

IT's certainly good business practice to buy the *best* oil seals, in order to have maximum protection for costly bearings. By using the proper KLOZURE oil seal, you may save the high cost of frequent bearing replacement.

To be sure of thoroughly dependable bearing protection, specify Garlock KLOZURE Oil Seals. They are tough and durable, resist oil and heat, stay firm and resilient. KLOZURES are made in a complete range of sizes and in many models, a few of which are illustrated.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK Klozure* OIL SEAL

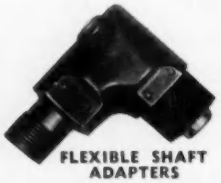
*REG. U. S. PAT. OFF.

They meet Performance Standards with Flying Colors!

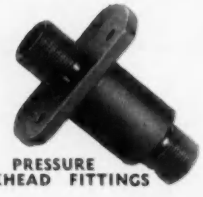
S.S.WHITE *Aircraft Accessories*

FLEXIBLE SHAFTS for power drive and remote control

ACTUATORS



FLEXIBLE SHAFT ADAPTERS



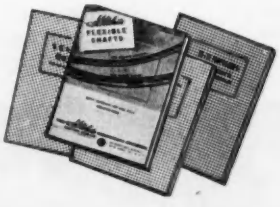
PRESSURE BULKHEAD FITTINGS

S.S.White flexible shafts and accessories are specified for practically every major military, commercial and civilian plane in use today. Their acceptance is based on the fact that they rigidly conform to the high standards set by the aircraft industry and have proven it by dependable, trustworthy performance under all flight conditions.

S.S.White's policy of combining quality materials and expert workmanship with expert engineering cooperation is your assurance of getting performance-proved products made to give the finest service. So, when specs call for flexible shafts, actuators, adapters or pressure bulkhead fittings, remember, "S.S.WHITE makes it right".

WRITE FOR FREE BULLETINS

Bulletin 5008 has the latest information and data on flexible shafts and their application. Descriptive material on other products also sent on request. Write stating your requirements.



THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. J, 10 East 40th St.
NEW YORK 16, N. Y.

New Members Qualified

Continued

Chicago Section

Barrett W. Cockrum (A), Victor Ross Floyd (J), Leslie C. Hardison (J), Leonard H. Keeve (J), Leonard M. Kulze (M), G. A. Lillieqvist (M), Richard A. Lindholm (J), Ray B. Melendy (A), William C. Moore (A), John Joseph O'Brien, Jr. (J), Arthur Devere Whitmer (M).

Cincinnati Section

Carl M. Klatte (M).

Cleveland Section

Joseph E. Adams (M), George F. Mullin (M), Benjamin David Richter, Jr. (J), Robert Roller (M).

Colorado Group

Walter H. Ketel (A), Ira Boyd Humphreys (M).

Dayton Section

Neal Granick (J), George F. Noltein (M).

Detroit Section

Elwood C. Bolles (M), Earl E. Borseth (J), Stanley L. Buckey (J), George Constantine Campbell (J), Robert E. Champe (A), Charles Breen Frederickson (J), W. J. Glynn (M), Howard G. Heinig (J), Edgar F. Kaiser (M), Anthony Lopucki (M), Robert W. Lotz (J), Richard Coy McCormick (J), Rex E. Phelps (J), James William Pilz (J), Lowell F. Sarnes (M), Jack G. Thom (J), Loren F. Van Nortwick (A), Richard L. Wheeler (M), Carlton Willrich, Jr. (J), Louis C. Zimelow (A).

Hawaii Section

Franklin P. Gomes (M), Lee O. Thompson (A).

Indiana Section

Donald Stephen Bowman (J).

Metropolitan Section

Oser I. Bermant (J), Benjamin Paul Fusco (J), Robert Kostelak (J), Kenneth Chris Mard (J), Edward John Schmidt (M), Sol Weil (A), Owen D. Yoder (J).

Mid-Continent Section

Allie O. Isom (J), Gilbert K. Ludwig (M).

Mid-Michigan Section

F. Gibson Butler (M), Leslie B. Smith (A).

Milwaukee Section

Paul M. Beard (J), Bob Edward Clement (J), Gordon S. Johnson (M), Wallace R. Johnson (J), Emmett

New Members Qualified

Continued

Charles Manning (J), Herbert P. Sampe (A).

Montreal Section

John Talbot Dyment (M), John W. Hammond (J), R. A. McLean (J), Edmund Allen Nix (M), Gordon M. Pfeiffer (A), Stanley S. Szczekowski (M).

New England Section

F. P. Broughton (M), Hubert Gardiner Hoben, Jr. (J), George C. Howe (A), Peter Stebbins (J).

Northern California Section

Ray Sulprizio (A).

Philadelphia Section

B. Russell Cowper (A), Wilfred R. Webb (A).

Pittsburgh Section

John S. Harper (M), W. B. Lenkard (A).

St. Louis Section

David F. Knost (A).

San Diego Section

William R. Dick (J), Harold Bond Hunting, Jr. (M), John L. Spefford (M), Arsham D. Zakarian (M).

Southern California Section

Edwin L. Cline (M), E. Richard Cooper (M), John T. Maddock (M), Gerhard Mauric (M), H. G. McIlroy (M), Paul J. Papanek (M), Gordon R. Steinhoff (M), W. Foster Word (A).

Syracuse Section

James H. Flournoy (J), Charles H. Sawyer (A).

Texas Section

A. G. Colburn, Jr. (J).

Virginia Section

Oscar Lee Dodson, Jr. (A).

Western Michigan Section

Ronald E. Wood (A).

Outside of Section Territory

Ollie Wayne Chandler (J), Lloyd L. Clevenger (J), Theodore G. Kush (M), Donald Lyon MacDonald (J), Wayne H. Newberg (A), Frederick J. Sanborn (A).

Foreign

Lt.-Col. Satish Chandra Ghosal (FM), India; Henry M. Haan (A), Belgium; Embree Moore Kennedy (FM), Brazil; Hassan Mariy (FM), Egypt; Col. P. V. Subramanyam (FM), India; Eiji Toyoda (FM), Japan.

IN THE AUTOMOTIVE FIELD, TOO . . .

LORD

VIBRATION-CONTROL

is part of design

Lord Mountings make the day's work easier for drivers, make the day's travel pleasanter for passengers, and make the journey safer for both. They postpone the day of repairs and replacements and reduce the costs of upkeep.

When you plan new buses, new trucks, new cabs, be sure that Lord Mountings are in the drawings and the specifications . . . make them a part of design. No other expenditure you make will bring as great returns from so small an outlay. Here are some of the places where Lord Mountings will serve you profitably:

- **Engine Mounts**
- **Radiator Mounts**
- **Instrument Mounts**
- **Air Condition Unit Mounts**
- **Ventilating Fan Mounts**

Write for your copy of the Lord Natural Frequency Chart and of the Vibration Isolation Chart. Designers and engineers will find them of definite value.

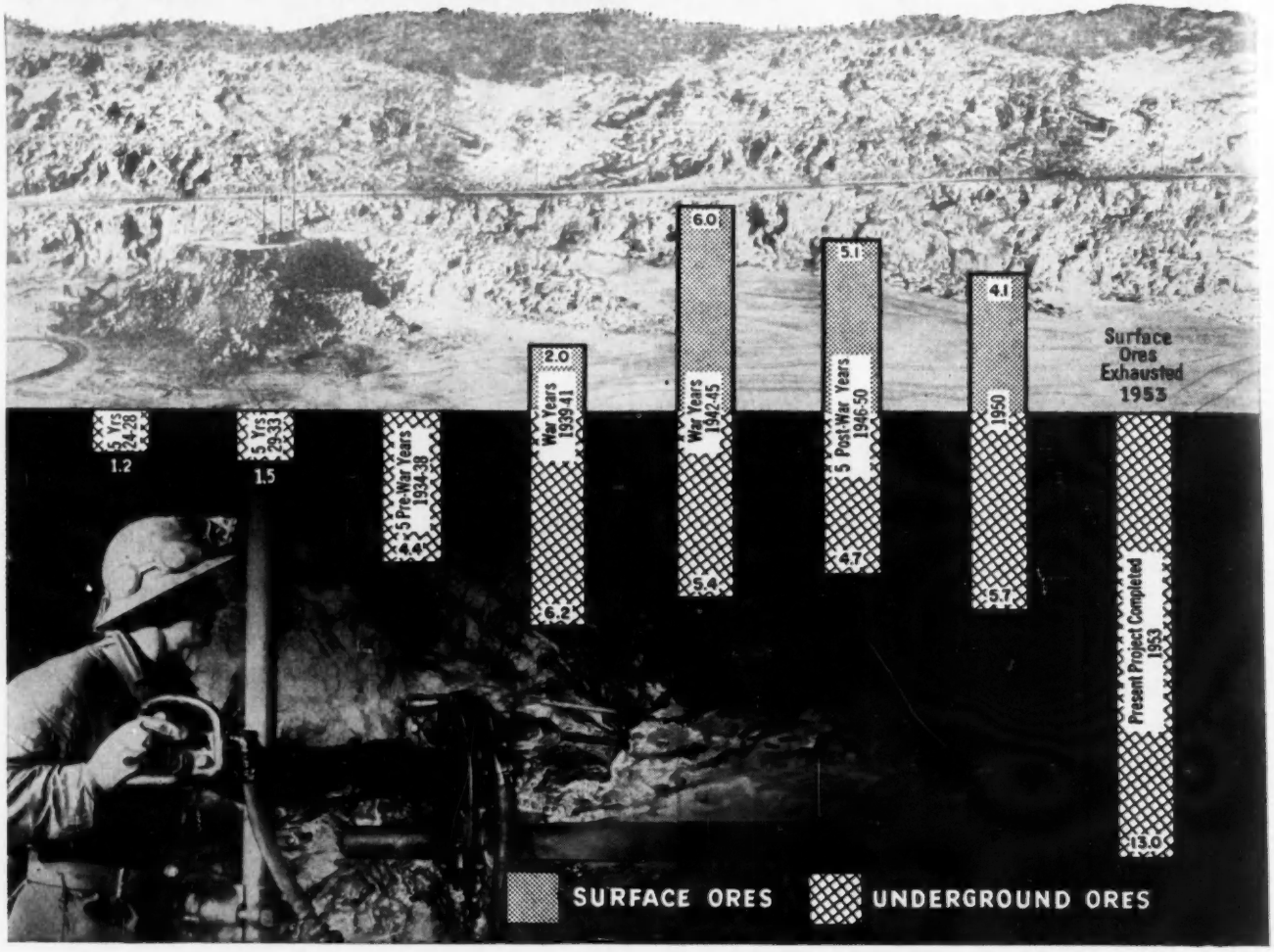
Although defense production is putting a heavy demand on our facilities, LORD will make every effort to supply industrial needs.

LORD MANUFACTURING COMPANY • ERIE, PA.

Canadian Representative, Railway & Power Engineering Corp. Ltd.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts



Underground for Defense

...started more than 10 years ago

STRENGTH...military and economic ...depends on productivity. And productivity depends on men who have devoted long years to their specialized chosen field of endeavour.

Such men with "know-how" mine nickel from the rocky rim of Ontario's Sudbury Basin...

By increasing output with maximum speed and drawing on reserve stocks of nickel previously accumulated, they helped raise deliveries of nickel in all forms during 1950 to 256,000,000 pounds...a record for any peace-time year.

This record, 22% greater than the 209,292,257 pounds delivered in 1949, was no accident...

In 1937, INCO launched a vast long-range project which now makes it possible to meet the military requirements of the United States, Canada and the United Kingdom. In addition, nickel deliveries are being made to government stockpiles and the balance of the supply is being rationed among civilian consumers in all markets throughout the free world.

Since the inception of International Nickel, its fixed policy has always been to increase the supply of nickel. To meet today's needs, INCO went underground years ago.

Anticipating the eventual depletion of Frood-Stobie open pit surface ores, more than 10 years ago, INCO embarked on a program of replacing open pit with underground capacity. This required extensive enlargement of underground plants, development of new methods of mining not previously undertaken and the revamping of metallurgical processes to cope with difficulties in recovering nickel from the new types and lower grades of ores which have to be reached.

Major expansion in output of nickel from underground operations is being driven to conclusion with utmost speed. There is still much construction to be done and a number of mining and metallurgical problems remain to be solved and tested in actual operation. Barring unforeseen interruptions, full conversion to underground mining should be completed in 1953.

When the present undertaking is completed, INCO will be able to hoist 13,000,000 tons annually, and the size of its underground mining operation will surpass that of any other non-ferrous base metal mining operation in the world.

This underground expansion is being completed by INCO without interrupting current production of nickel, which is at maximum capacity.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

For the Sake of Argument

One Thing Leads to Another . . .

By Norman G. Shidle

"We need to get the best out of every engineer in our organizations in these manpower-shortage days," Bell Aircraft's Bob Woods remarked to some fellow SAE Councilors the other day. "Enough qualified men to do all we have in mind, simply don't exist. So, we had better make sure we are using existing capacities to the limit." . . . . Few of us are, everybody seemed to agree.

"Well, knowing what's already been done, before plunging ahead on new projects, is one good way to prevent manpower wastage," Past-President Reg Pigott contributed. "A search of pertinent technical literature almost always pays off. There's a good chance somebody has already met and solved some of your current problems. But it's amazing how often action precedes a checkback."

Those checkbacks, somebody else thought, are fairly easy for the man who knows how and where to look; painful to others. The engineer who learned to use libraries and reference works early in his career has a big advantage. While his confrere is writing letters to people he hopes might know, he spends an hour with the bound volumes or current card service of Engineering Index. And before the "Sorry, don't know" letter has come back to his confrere, he has a complete list of pertinent articles—and some information about what they contain. Then another few hours in the library, and he knows exactly where he stands.

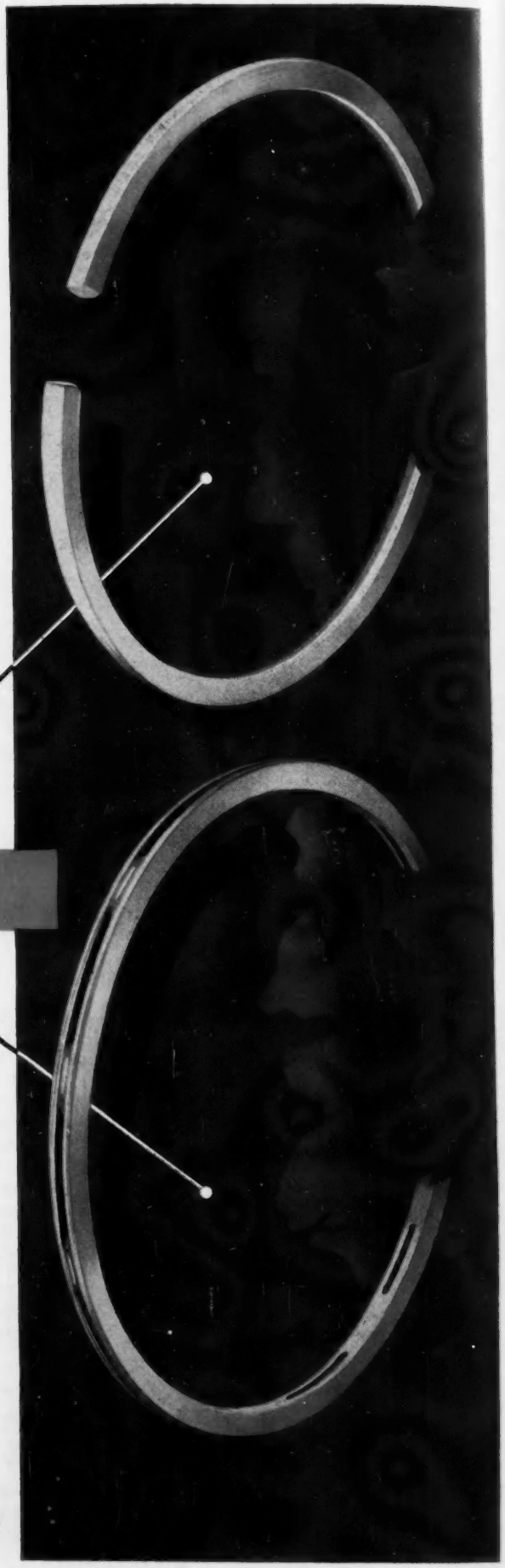
He knows the use of other less technical reference works, too. Things like Industrial Arts Index, Cumulative Book Index, and Readers' Guide to Periodical Literature. But his experience tells him that Engineering Index alone will often meet his needs.

Said one engineer the other day: "A course in how to know and use libraries and standard reference books ought to be compulsory in engineering colleges!" Actually, a few colleges are beginning to agree with him. Several such courses have been established.

Efficient use of reference books can be a major contribution to preventing wastage of man-hours on already solved problems.

McQUAY-NORRIS

PISTON RINGS



TIME TESTED
McQUAY NORRIS
PISTON RINGS
PROVEN IN SERVICE

Tried, and proved for over 40 years, the performance of McQuay-Norris piston rings is assured...and they are specifically engineered to meet every requirement, no matter how exacting.

McQUAY-NORRIS MANUFACTURING CO.
ST. LOUIS 10, MO.